

**The Rules of Perception: American Color Science, 1831-1931**

by

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Bachelor of Arts  
Columbia University, 2005

Submitted to the Program in Science, Technology, and Society  
in Partial Fulfillment of the Requirements for the Degree of

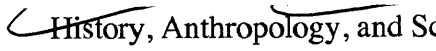
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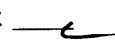
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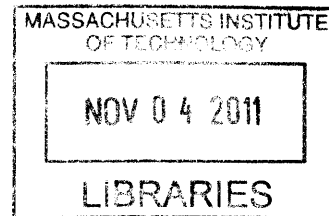
  
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# The Rules of Perception

## American Color Science, 1831-1931

By Michael Rossi

Submitted to the Program in History, Anthropology and Science, Technology, and Society in Partial fulfillment of the requirements of the Degree of Doctor of Philosophy in History, Anthropology, and Science, Technology and Society.

### Abstract

Although vision was seldom studied in Antebellum America, color and color perception became a critical field of scientific inquiry in the United States during the Gilded Age and progressive era.

Through a historical investigation of color science in the United States in the late nineteenth and early twentieth centuries, I argue that attempts to scientifically measure, define, and regulate color were part of a wider program to construct a more rational, harmonious, and efficient American polity starting from one of the very baseline perceptual components of reality – the experience of color. As part of this program, I argue secondly that color science was as much a matter of prescription as description – that is, color scientists didn't simply endeavor to reveal the facts of perception and apply them to social problems, they wanted to *train* everyday citizens to *see scientifically*, and thereby create citizens whose eyes, bodies, and minds were both medically healthy and morally tuned to the needs of the modern American nation. Finally, I argue not simply that perception has a history – i.e. that perceptual practices change over time, and that, for Americans of a century ago, experiences of color sensations were not taken as given but had to be laboriously crafted – but also that this history weighs heavily upon our present day understanding of visual reality, as manifested not least of all in scientific studies of vision, language, and cognition.

Employing a close reading of the archival and published sources of a range of actors including physicist Ogden Rood, semiotician Charles Peirce, logician Christine Ladd-Franklin, board game magnate Milton Bradley, and art professor Alfred Munsell, among others, this study reveals the origins of some of the most deeply-rooted conceptions of color in modern American culture.

Thesis Supervisor: David S. Jones

Title: Professor of the Culture of Medicine, Harvard University (formerly MIT STS)





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# Acknowledgments

While historical scholarship is a notoriously lonely endeavor, I never felt alone through the researching and writing of this dissertation. The kindness and generosity of my colleagues and friends kept me afloat, kept me on track, and kept me inspired from start to finish, and it is to them that greatest thanks is due.

It is appropriate to begin by thanking my committee, without whom this project could not have gotten off the ground. My primary advisor, David Jones, was a tireless reader, bountiful source of good advice, and subtle but profound suggestions; for his patience and enthusiasm in teaching me how to be a professional historian, I am grateful. Stefan Helmreich, likewise, was a constant wellspring of surprising ideas and orthogonal approaches, and his entreaties to sharpen my ideas made this work function better as a whole. I am indebted to Christopher Capozzola not only for his boundless erudition and his sense of humor, but also for the ways in which he encouraged me to keep the everyday humanity of my subjects in constant focus. Caroline Jones's unsparing barrage of margin notes – including the half-dreaded, half-beloved “thesis flag” – forced me to tie my ideas to the empirical bedrock that underwrites good history, even as she encouraged me to shoot for the moon.

In addition to my committee members, several scholars who were not on my committee nevertheless gave openhandedly of their time and energy. In both his lunchtime workshops on the history of physics, and his class seminar on formalisms, David Kaiser was a terrifically magnanimous reader and commenter of chapter drafts; chapter five in particular owes much to his interventions. Craig Wilder read and commented on an early draft of chapter two, and on more than one occasion thereafter I discovered the unmatched pleasure of geeking out on nineteenth century Presbyterian history with him – I can only hope that I've done at least some justice to our conversations in this study. A single reading session on gaslight in Victorian Britain with Harriet Ritvo and Chris Capozzola had profound reverberations in my thinking about writing this dissertation, as did a workshop with Bruno Latour – these sessions and these scholars opened up new vistas for me in approaching the material with which I was wrestling. I must also thank Vincent Lepinay, for his encouragement and enthusiasm about my project.

The community of graduate students with whom I worked at MIT were truly an interdisciplinary bunch of scholars, interested in fields as disparate as law, food, farming, mathematics, biotechnology, psychiatry, and physics (to name just a few). I found in their comradeship, nevertheless, a common current of heartfelt interest and shared enthusiasm in the science studies work in which we were all engaged. Among the many great people I met at MIT, Orkideh Behrouzan, Laurel Braitman, Kieran Downs, Xaq Frohlich, Chihyung Jeon, Shekhar Krishnan, Teasel Muir-Harmony, Jamie Pietruska, Tom Schilling, David Roth Singerman, Ellan Fei Spero,

Michaela Thompson, Nate Deshmukh Towery, Rebecca Woods, Benjamin Wilson and Sara Wylie all contributed much to this manuscript, and were good friends, as well. Lisa Messeri, Alma Steingart, and Sophia Roosth were also good friends, and were good office mates, as well – although they were sometimes a bit distracting, with all of the good food and entertaining conversations that they brought through E51-098. Alex Wellerstein, while not an MIT student, could be counted on to have good things to say about matters scholarly and otherwise, and to say them with great aplomb.

The footnotes and bibliography of this text should be thought of as a specialized sort of thank-you to the scholars and subjects on whose work and life this study is based. Distance and time made it impossible for me to work personally with most of these individuals, but there were some pleasurable exceptions. I met Marie Frank while looking at Denman Ross's papers at Harvard, and she not only shared her expert knowledge of his life and works, but also helped in some cases to interpret his inscrutable handwriting. Anthropologist David Howes's published work provided an intellectual framework for many of the questions addressed in this study, and his feedback on an early chapter draft was kind and helpful. Emily Gephart's scholarship on nineteenth century artists and science enthusiasts in Boston and New York shaped this study in ways too numerous to describe, as did her readings and comments on most every chapter; she also brought me some fine dilly beans, for which I am grateful. Discussions I had with Jill Morawski at a conference in Cachan, France, were formative to the ways in which I came to think about chapter 4.

Archivists are a special breed of scholar, and deserving of no small reverence. Paul Dobbs is a historian of color science and an archivist at the Massachusetts College of Art and Design. He and Richard McElroy helped me navigate their magnificent Munsell collection, and were giving both of their time and their amazing array of artifacts. Jane Callahan at the Harvard Art Museum was similarly great about showing me around the archive's collection of Denman Ross material. Nora Murphy at MIT's Institute Archives & Special Collections was tenacious and terrific to work with, and Anita Perkins was tireless in tracking down the identity of a particularly mysterious publication for me. Thank you to Daniel Lewis at the Huntington Library for his helpful offerings of Ridgeway and Bradley correspondence.

I presented portions of chapters in various states of completion at a number of conferences. Sophia Roosth organized a panel at the 2009 Society for the Social Studies of Science conference on "Making Things" that allowed me to craft the beginnings of chapter five – so she was a great organizer and inspiration as well as office-mate. Thank you to Jennifer Roberts for inviting me to participate in the "Multiplying the Visual" conference at Columbia University, and to Elizabeth Hutchinson for moderating the panel on which I spoke. The participants of "Physics Phunday," in 2010 at Princeton University, contributed valuable input to what would become chapter two. And PJ. Brownlee's panel on "Color in Nineteenth Century American Painting," at the 2010 College Art Association meeting gave me an opportunity to confer with art historians on the mutually-interesting topic of color.

Financial support for much of this dissertation was provided by MIT's Program in History, Anthropology, and Science, Technology and Society. I wrote early stages and did substantial research and thinking under the aegis of MIT's NSF/IGERT Program on Emerging Technologies of which I was a fellow. Special thanks in this capacity are due to Ken Oye, and especially to Larry McCray, whose friendship and support have meant more to me over the past four years that I've known him than perhaps he is aware. MIT's Center for International Studies funded a critical summer of research in 2009. A Dissertation Completion Fellowship from the Andrew W. Mellon/American Council of Learned Societies Early Career Fellowship program supported my final year of research and work.

In the STS, HTC, and History offices, Alex Aho, Kate Brearley, Jerry Burke, Sarah Fowler, Karen Gardener, Kris Kipp, Debbie Meinbresse, Paree Pinknee, Rose Rizzo, Bianca Singletary, and Judy Spitzer offered help, hope and resources in dealing with the often labyrinthine bureaucracy of MIT.

A special thank you is due to Janice Dolan for the moral support and practical advice of which she was a constant source; she was always there through the rough patches and fair. And thanks also to the crew at Zazil Media Group – Brittany Cook, Katherine Connors, Kathleen Langlois, and Cara Zambri – for all of the good times, and for their love of mushrooms, sequins, and the history of science.

Over the course of my graduate studies – and, indeed, throughout the often peripatetic preceding years – my family has always been there for me. Dad, Mom, Loretta, and Joe were a source of strength and inspiration for me, and one day I would like to share their sense of wisdom and confidence. This goes double for my in-laws. Thank you to Wendy and Arnold (favorite-father-in-law) for their unwavering support, leavened with strident advice, and lots of good humor. Brothers: my plan was to blame the faults of this dissertation on my brother, Matt, but it seems unfeasible. Instead, I'll just say thanks for all of the readings and good thoughts. Jason Hoffmann – I knew we'd be friends when I met him, and though it's not his fault that we ended up brothers-in-law, I couldn't be happier. Jason and Joey – you know who you are – this is a shout out to my boys in Philly.

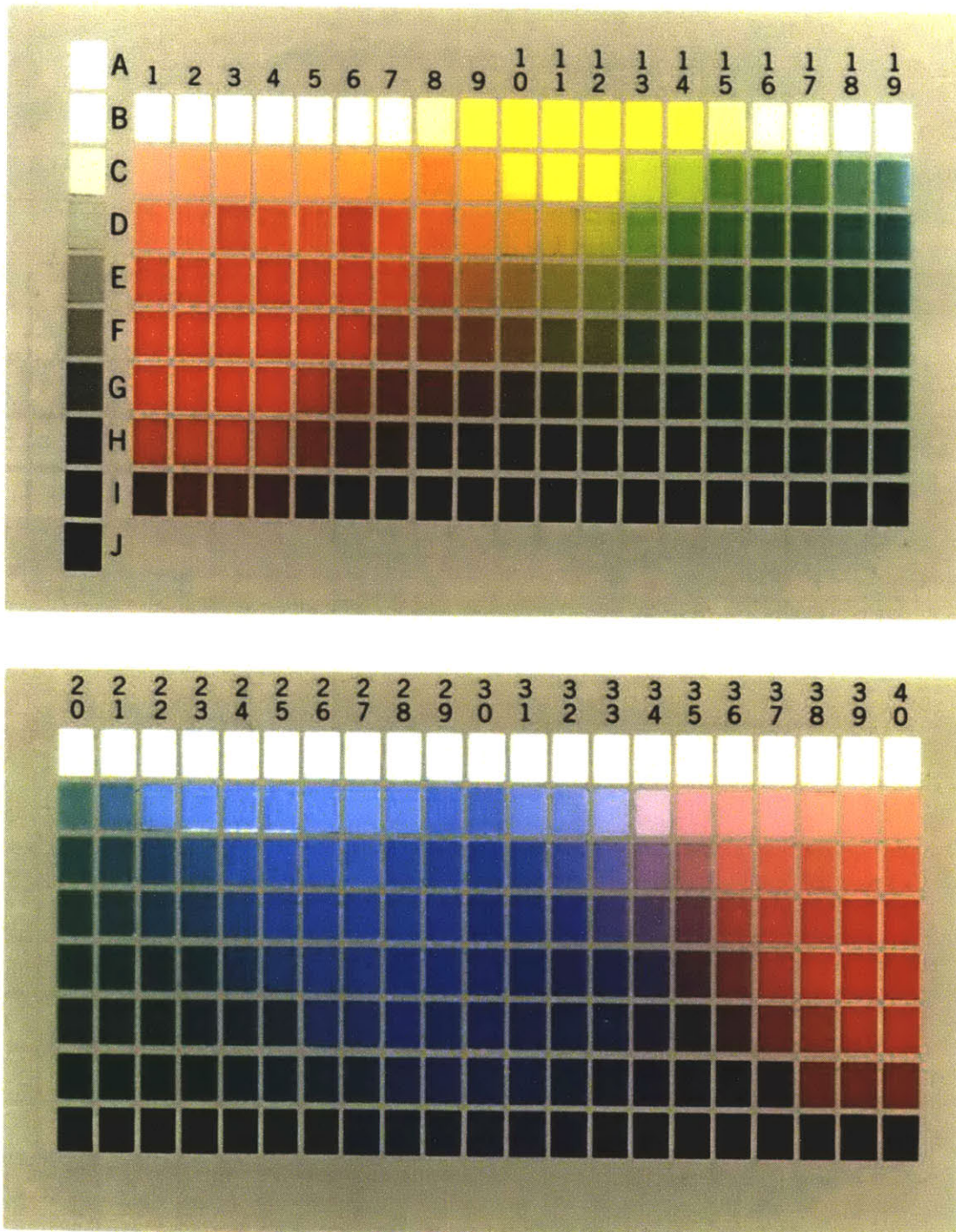
Much of the following text describes various actors' attempts to come to grips with the limits of language. Perhaps fittingly, I will therefore end by saying that there are no words to describe my love for Maude, Apollonia, and Jennefer. I am grateful to them for all of the laughs, the adventures, and the light and color that they bring to my life, and I love them more than I can say.



## **Illustrations**







**Figure 1.1:** A standardized Munsell array used in psycholinguistic research. From C.L. Hardin, Luisa Maffi, eds, *Color Categories in Thought and Language* (Cambridge: Cambridge University Press, 1997).



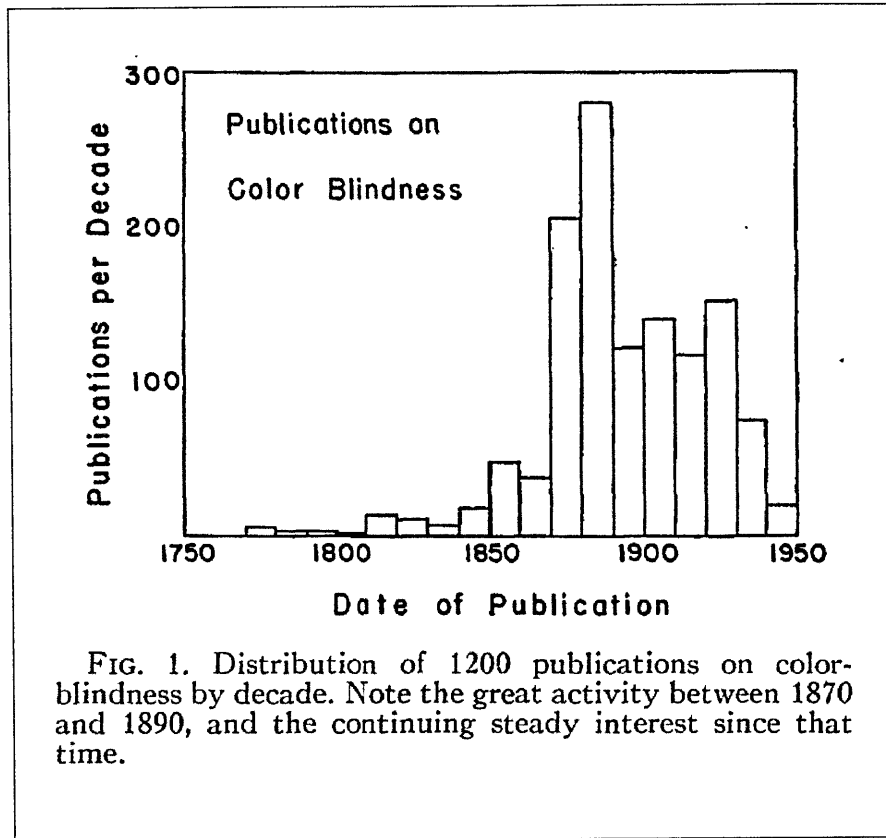
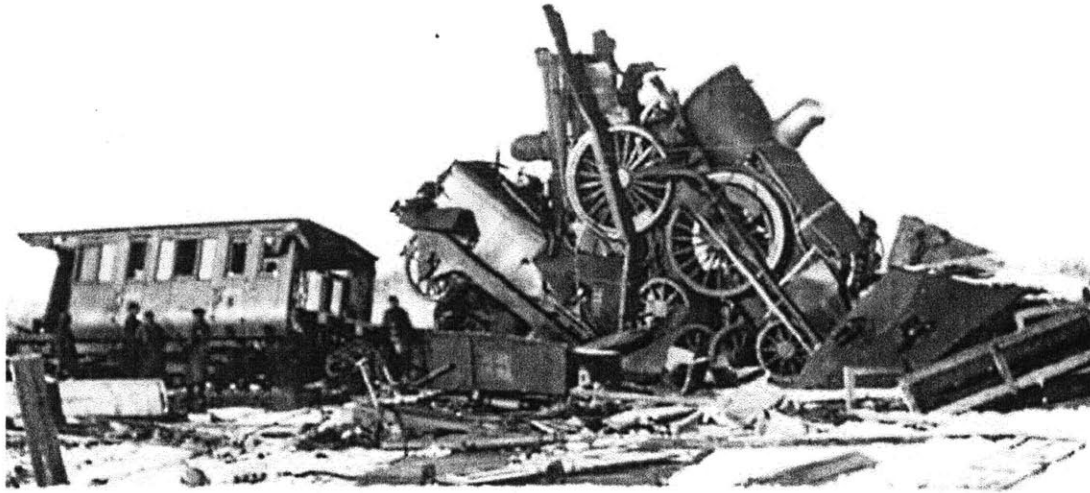


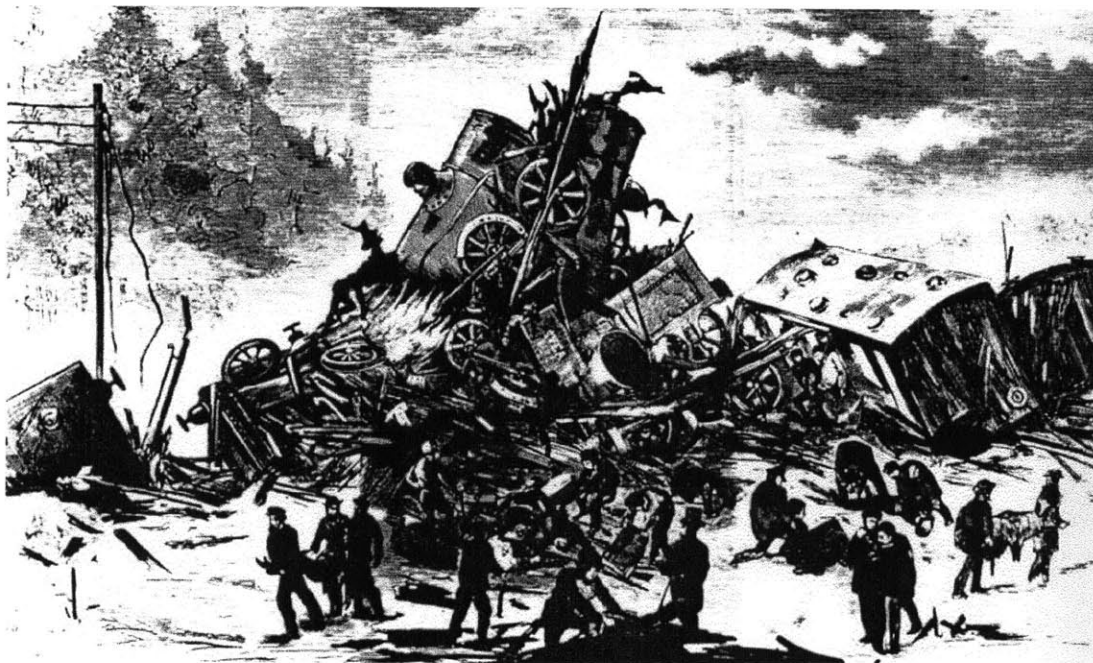
FIG. 1. Distribution of 1200 publications on color-blindness by decade. Note the great activity between 1870 and 1890, and the continuing steady interest since that time.

**Figure 3.1:** Publication history of color blindness literature. Deane B. Judd, the author of this chart, was both a leading color scientist at the U.S. National Bureau of Standards in the 1920s, '30s and '40s, as well as an active chronicler of the field of color science. He does not specify sources, but presumably the publications graphed above comprise the worldwide output of literature on color blindness. (Deane B. Judd, "Facts of Color Blindness," *Journal of the Optical Society of America*, 33:6, Jun. 1943, pp. 294 -307, on pg. 295).





**Figure 3.2:** Lagerlunda train crash, 1875. Above is a photo taken at the scene; below an etching by Swedish artist, Carl Larsson. Larsson's horrific sketch of the accident was one of the factors motivating public outrage over the crash, and a subsequent movement to implement widespread color testing in Sweden and later, across Europe and the United States. (Carl Larsson, *Carl Larsson: the Autobiography of Sweden's Most Beloved Artist*, trans. John Z. Lofgren (Iowa City, Iowa: Penfield Press, 1992) pp. 72-73. Photograph: Swedish Railway Museum; Ängelholm, Sweden).





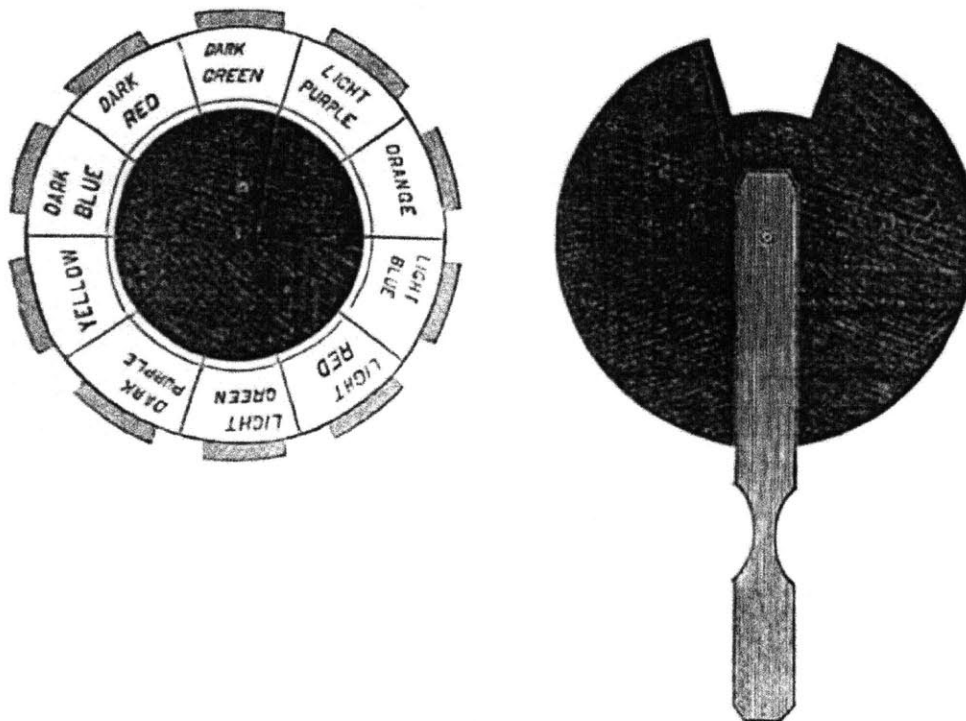
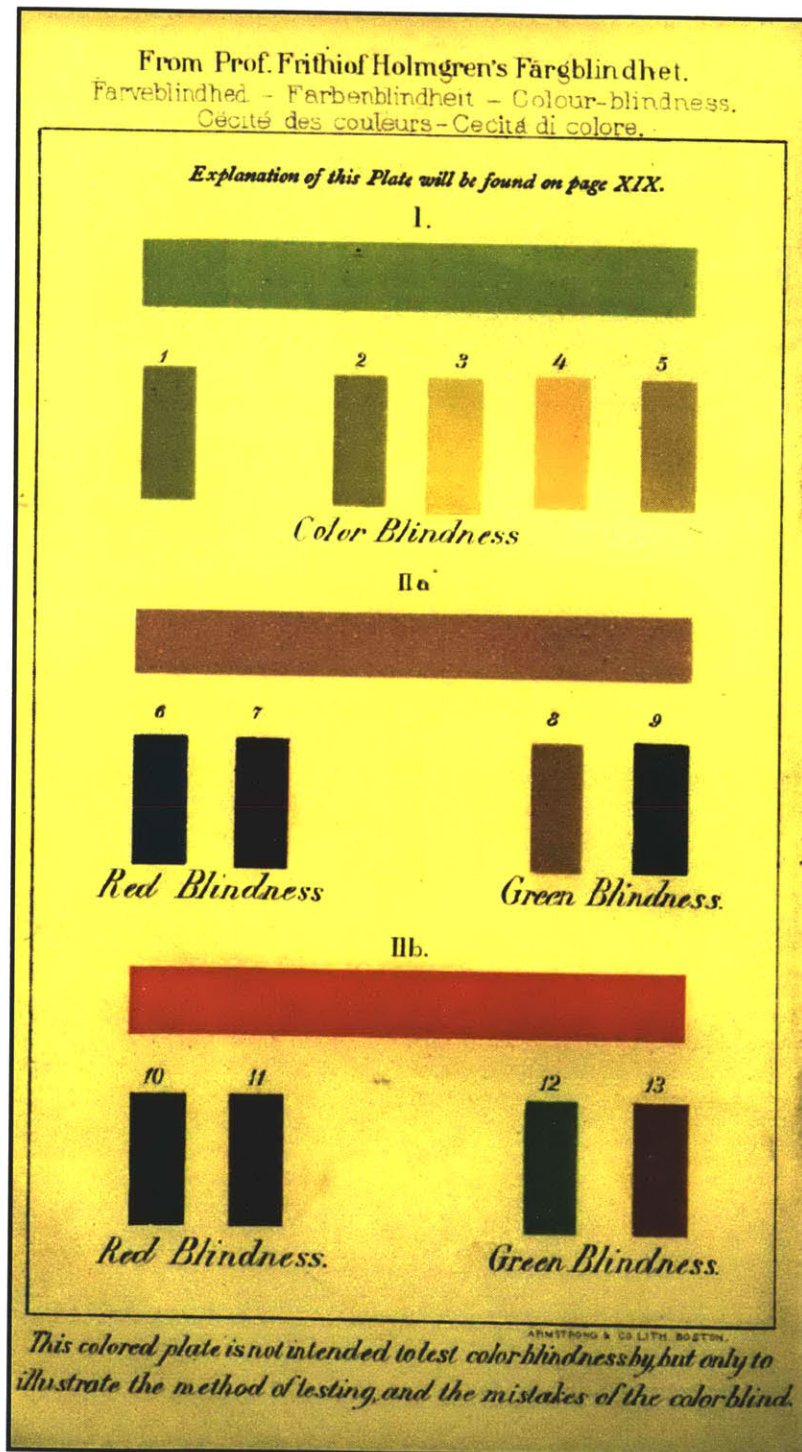


FIG. 1.

**Figure 3.3:** "An Apparatus for Testing the Perception of Color." The subsidiary disk bore colors of the experimenter's choosing, which could be rotated until revealed in the window of the covering envelope. By ordering the test subject to maintain a fixed gaze while the experimenter moved the disk around the subject's field of vision, it was possible to map the color sensitivity of the subject's field of vision. (Henry N. Noyes, "An Apparatus for Testing the Perception of Color," *Transactions of the American Ophthalmological Society Annual Meeting*, 1:8, 1871, pp. 118-119, on pg. 119).

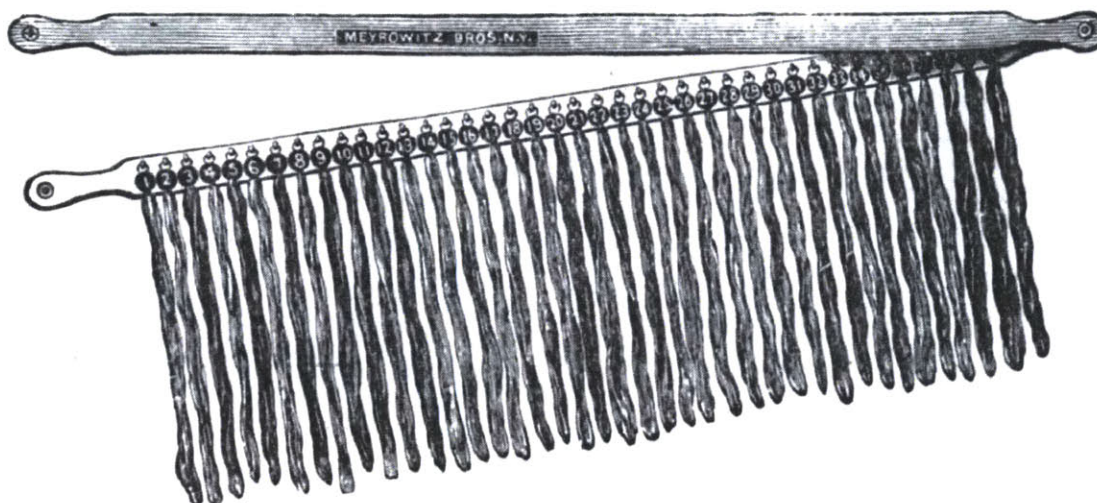






**Figure 3.4:** Plate for picking test wools. This print served as a guide for ophthalmologists in picking wools for Holmgren's color blindness test. The horizontal bars represent test colors; the vertical bars represent "confusion" colors. (Benjamin Joy Jeffries, *Color Blindness: Its Dangers and Detection*, (Boston: Osgood and Co, 1879) frontispiece).

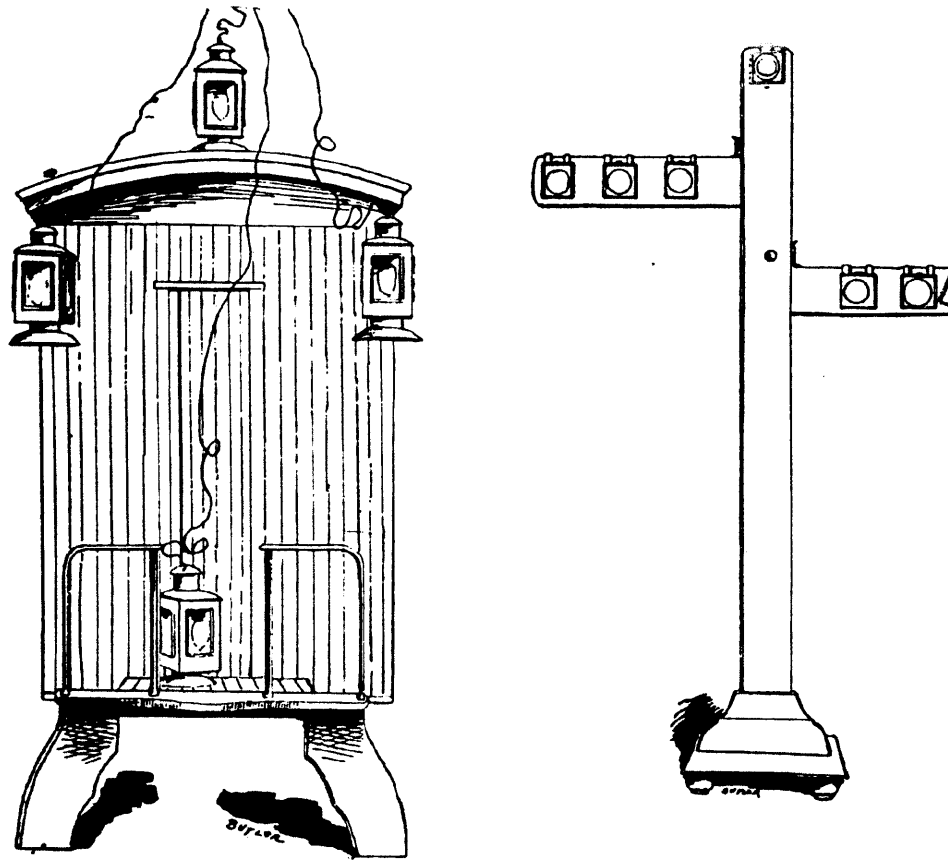




**Figure 3.5:** Thomson's "stick" in black and white, and color. Note the numbers attached to the threads on the above illustration, as well as the imprimature of Meyrowitz Brothers, of New York – a company that specialized in supplying reliable materials and devices for color acuity testing. The bottom illustration gives a sense of how Thomson's colors correspond to Holmgren's. Not shown are the three control skeins, which would be handed to the test-taker, and which corresponded in color to Holmgren's green, rose and red wools. (above: John Ellis Jennings, *Color Vision and Color Blindness: a Practical Manual for Railroad Surgeons* (Philadelphia: F.A. Davis Company, 1886) on pg 67; below: "Cover Photograph," *British Journal of Ophthalmology*, 93:32, 2009).



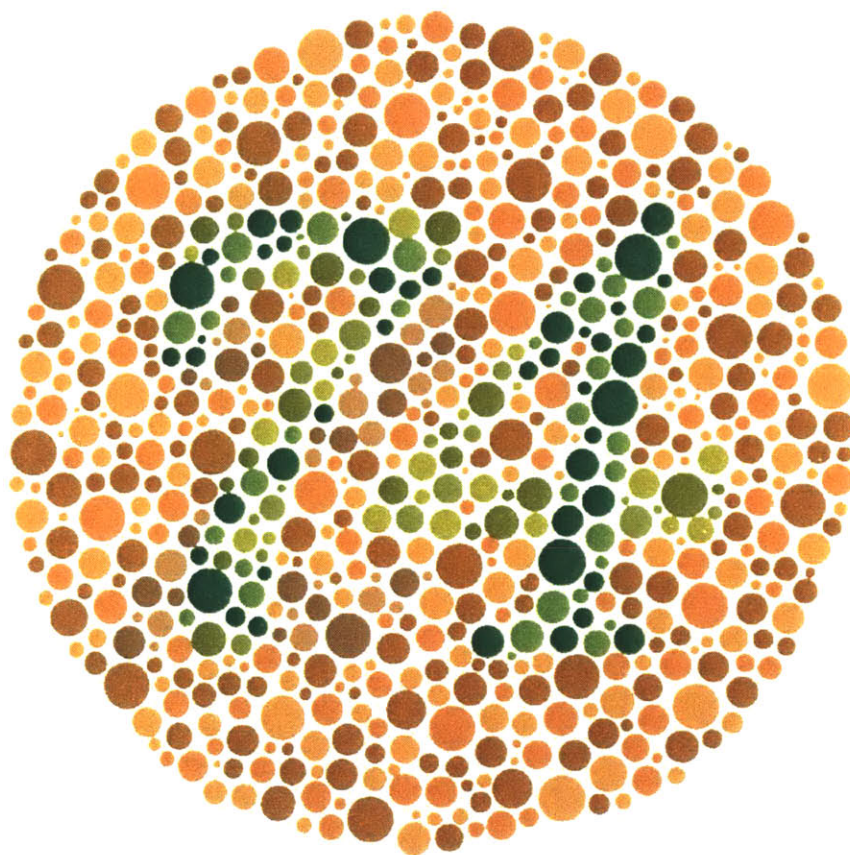




**Figure 3.6:** Railroad surgeon Emmet Welsh's faux-caboose-color-blindness-testing apparatus. That Welsh felt such extravagant subterfuge necessary in order to guarantee the results for his color acuity tests speaks to the uncertainty among late nineteenth century physicians – to say nothing of railroad men – about the viability of abstracting sensual knowledge from everyday experience. (Emmet Welsh, "Color Blindness," *The Railway Surgeon*, 1:1, 5 Jun. 1894, pp. 8-11, on pg 9).



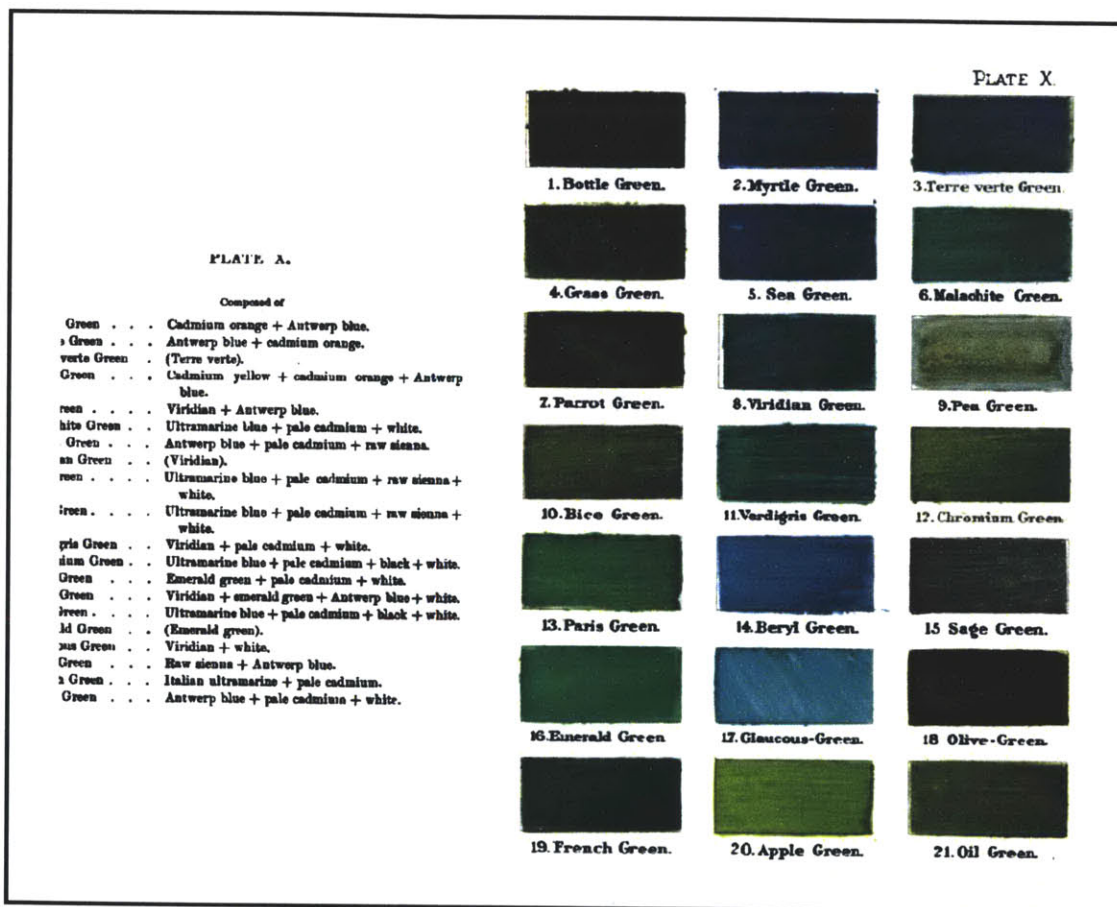




**Figure 3.7:** One of Shinobu Ishihara's "pseudoisochromatic" plates. The test is described as *pseudoisochromatic* because to individuals without color blindness, the a green "74" appears in the middle. To many people with a variation in color acuity, the plate simply appears to be a field of similarly-colored (or, "isochromatic") circles.

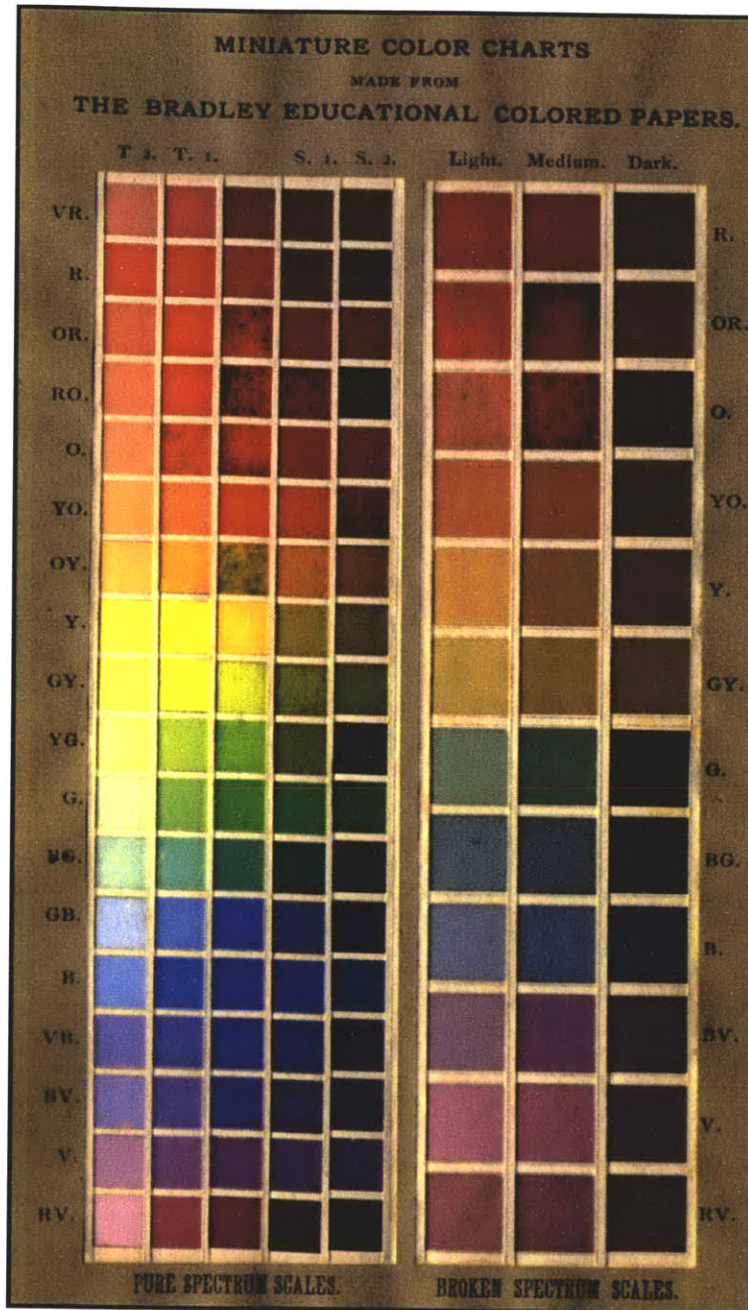






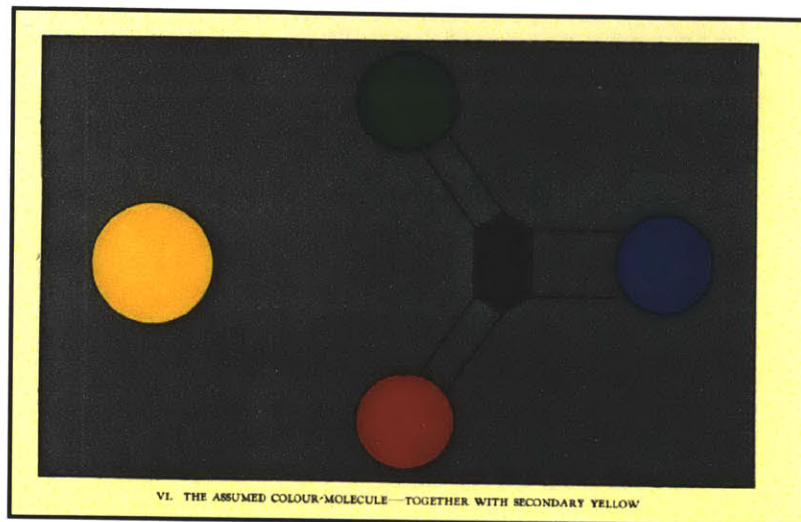
**Figure 4.1:** A plate from Robert Ridgway's 1886 book, *A Nomenclature of Colors for Naturalists and Compendium of Useful Knowledge for Ornithologists*. On the left are the "recipes" for making the colors; on the right, the chips painted with the colors, some still bearing brushstrokes. (Robert Ridgway, *A Nomenclature of Colors for Naturalists and Compendium of Useful Knowledge for Ornithologists* (Boston: Little, Brown and Company, 1886)).



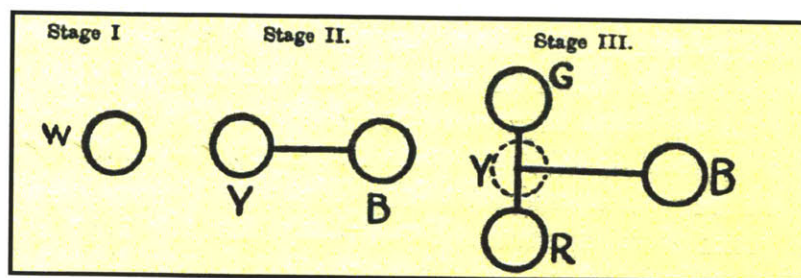


**Figure 4.2:** Frontispiece to Milton Bradley's *Elementary Color* displaying Bradley's 90 original "pure spectrum" colored papers. Notice the table arranged according to Bradley's alphanumeric system, with "T" standing for "tint" – that is, a color made with white, and "S" standing for "shade" – a color made with black. The "broken" colors to the left of the pure spectrum colors were mixtures of spectral colors plus a proportion of their complementary colors. (Milton Bradley, *Elementary Color*, (Springfield, MA: Milton Bradley Company, 1885)).



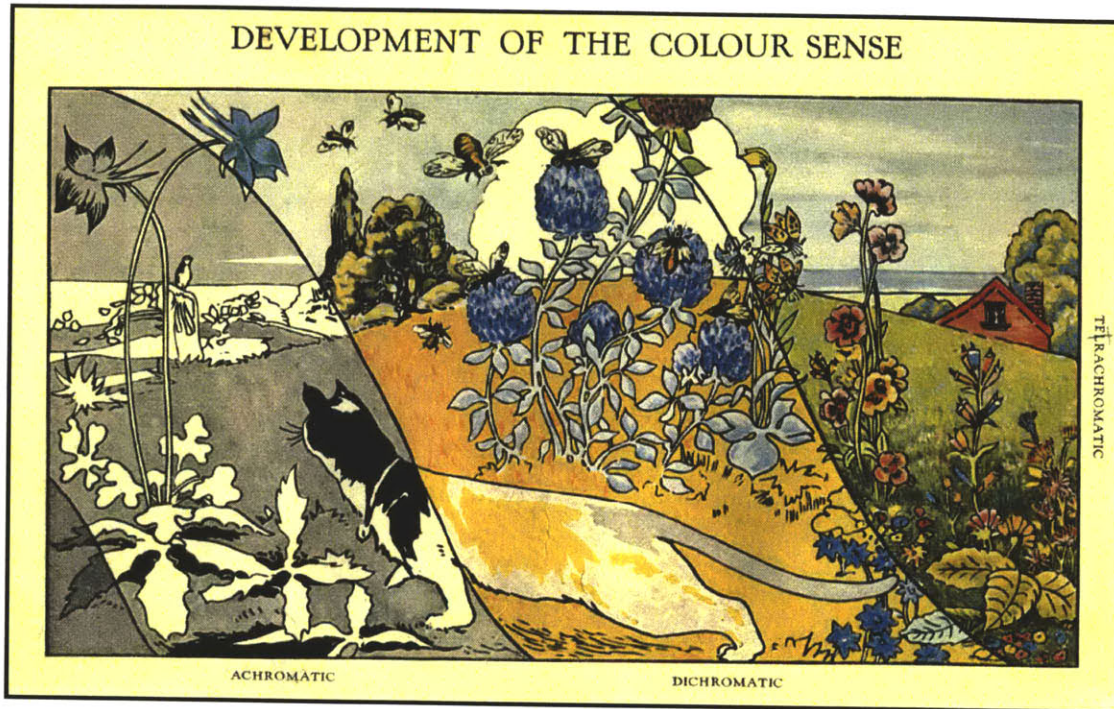


**Figure 4.3:** Two views of Ladd-Franklin’s color-sensitive “molecule.” The top view depicts the molecule’s three “receptors” (or “resonators, side-chains, light-sensitive electrons or whatever the current photo-chemical theory calls for” as Ladd-Franklin wrote (129)). The bottom view gives a schematic of the molecule’s evolution. Both, Ladd-Franklin took pains to point out, were “theoretical” – though in her view, the ways in which people talked about their visual experiences substantiated her theories. (from Christine Ladd Franklin, *Colour and Colour Theories*, (London: Kegan Paul, Trench, Trubner & Co, 1929)).









**Figure 4.4:** Pictorial view of Ladd-Franklin's proposed three stages of color perception. Note that the animal species are representatives of different sorts of color vision – cats, for instance, possessed achromatic vision, while bees could see combinations of yellow and blue. Indeed, this picture is not just an illustration of how different species see; it's also a view through time. As Ladd Franklin put it

In Carboniferous times, when there were no coloured birds and no coloured flowers, a colour-sense would have been of no use to the low animals which existed-their vision was achromatic. (That of the cat and of other night-prowling animals is achromatic still.) In the Cretaceous period came in together bees and coloured flowers. But the bees [...] see two colours only (yellow and blue) like our own atavistic partially colour-blind individuals, their vision is dichromatic. With birds, most mammals, and normal human beings, yellow has been differentiated into red and green-vision has become tetrachromatic (279-280).

In a similar vein, Garrett P. Serviss, a science popularizer, wrote in the *New York Evening Journal* that Ladd Franklin's theory gave "glimpses [...] of the way the world looks, and has in much earlier times, to creatures other than ourselves" and in so-doing could "help to throw light upon the problem of the manner of man's origin, and his relationship to other animals." Indeed, after rhapsodizing about how "the animal contemporaries of the coal-forming plants [...] saw no play or gleam of color anywhere, however the sunbeams at their busy work of storing up thermal energy for use in the coming age of man may have been spectrally splintered," Serviss looked towards the future of humankind, wondering if there might be yet undiscovered colors, if the retina had not yet "reached its highest stage of development." (see, Garrett P. Serviss, "Garrett P. Serviss on Color Influence" *New York Evening Journal*, 28 June 1922; picture from from Christine Ladd Franklin, *Colour and Colour Theories*, (London: Kegan Paul, Trench, Trubner & Co, 1929)).







65. CHLORIS CALLS. A. H. MUNSELL.

**Figure 5.1:** An engraving of Munsell's 1885 watercolor, "Chloris Calls." The artifact behind the figure depicted a combination sundial and color wheel - the sections were painted to indicate the correct positions of different colors. As such, the painting serves as an allegory for both chronoception and chromoception. (From *Catalogue of the Thirty-Second Exhibition of the Boston Art Club Water Colors, Black and White Drawings, and Sculpture, Held at the Club Gallery* (Cambridge: Riverside Press, 1885) pg 18).



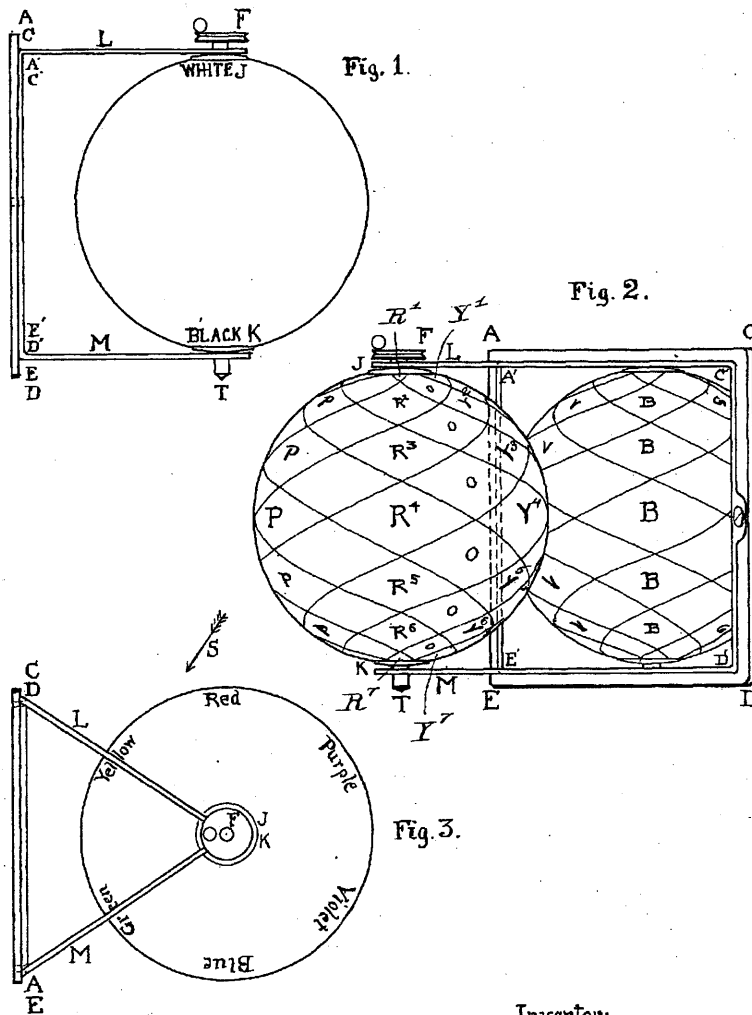
No. 640,792.

Patented Jan. 9, 1900.

A. H. MUNSELL.  
 COLOR SPHERE AND MOUNT.

(Application filed Apr. 14, 1899.)

(No Model.)

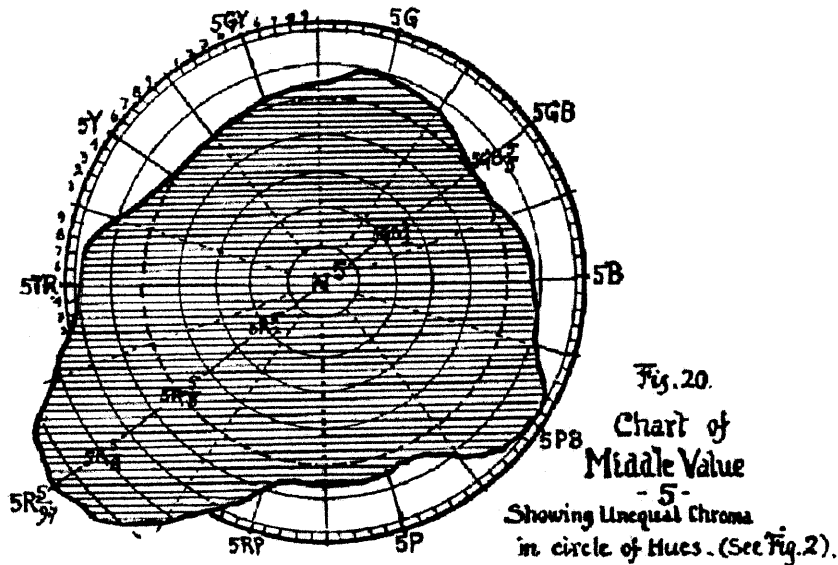
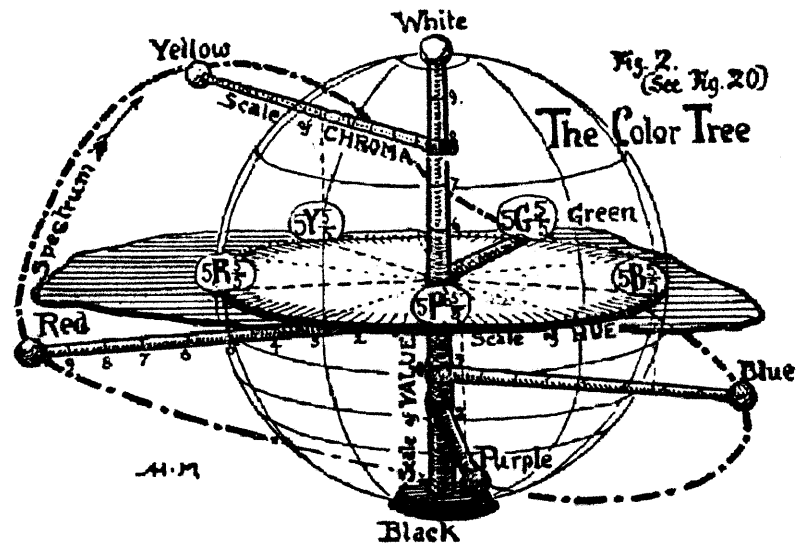


Witnesses: *Juliet C. Munsell* *Margaret C. Munsell* Inventor: *Albert H. Munsell*

THE NEWBERRY CO., PHOTO-LITH., WASHINGTON, D. C.

**Figure 5.2:** Illustrations of Munsell's patented "color sphere." The spiral lines along the surface of the sphere in Fig. 2 were intended to map harmonious color combinations. Note mirror behind the sphere, so that all color relations could be apprehended at once. For ease of use, Munsell dropped the idea of the spiral lines in the manufactured sphere, and eliminated "violet" as a cardinal color. (From Albert Munsell, 1900, Color Sphere and Mount, U.S. Patent no. 640, 792, filed 14 Apr. 1899, and issued 9 Jan. 1900).

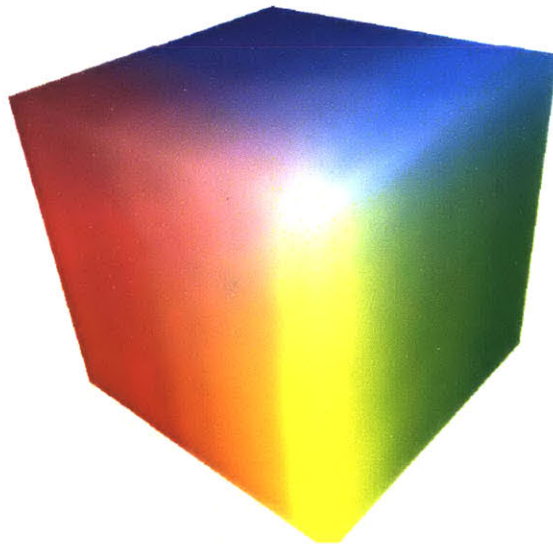
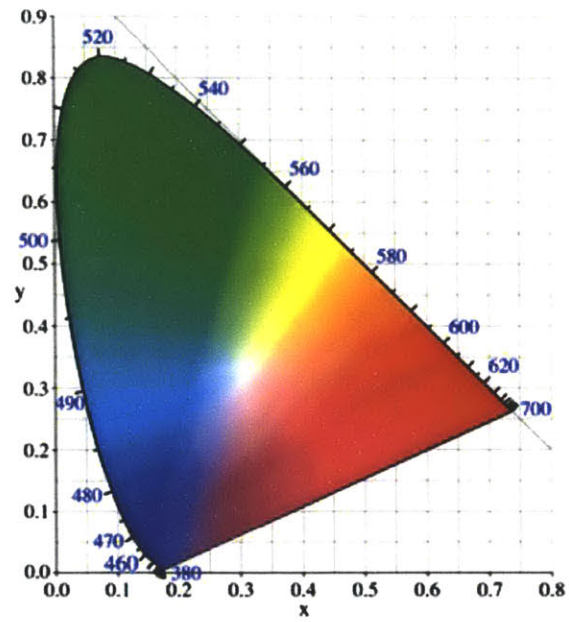




**Figure 5.3:** Munsell's measured color solid, or "tree." For purposes of primary education, Munsell advocated retaining the simpler spherical shape, though his physiological research suggested that the true form of the color solid would be irregular. The salient in the bottom cross section is formed from the very intense red portion of the spectrum projecting beyond the chromatic highs of the other colors. Note the nomenclature - 5R 5/9 - indicating that the red value at the tip of the salient is located exactly in the middle of the red band of the solid, midway up the "y" (or "value") axis, with a high chroma, or saturation, of 9.7. (From A.H. Munsell, *Color Notation* (Boston: George Ellis and Co., 1905) on pg. 23 and pg. 74).



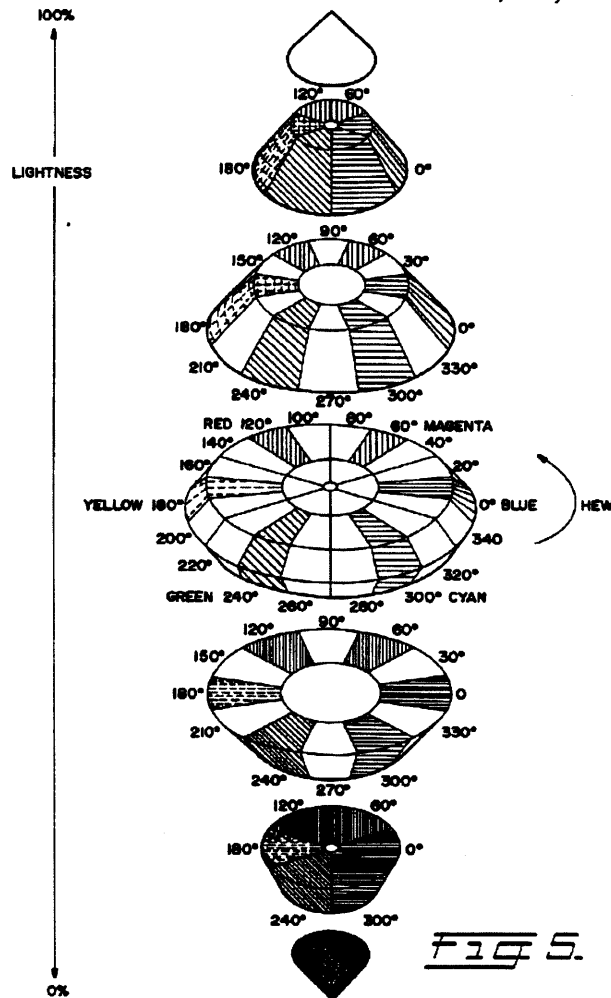
Illustrations



**Figure 6.1:** CIE 1931 color space (top) and RGB color "cube" (bottom). Note the relatively large area of green on the CIE 1931 diagram.

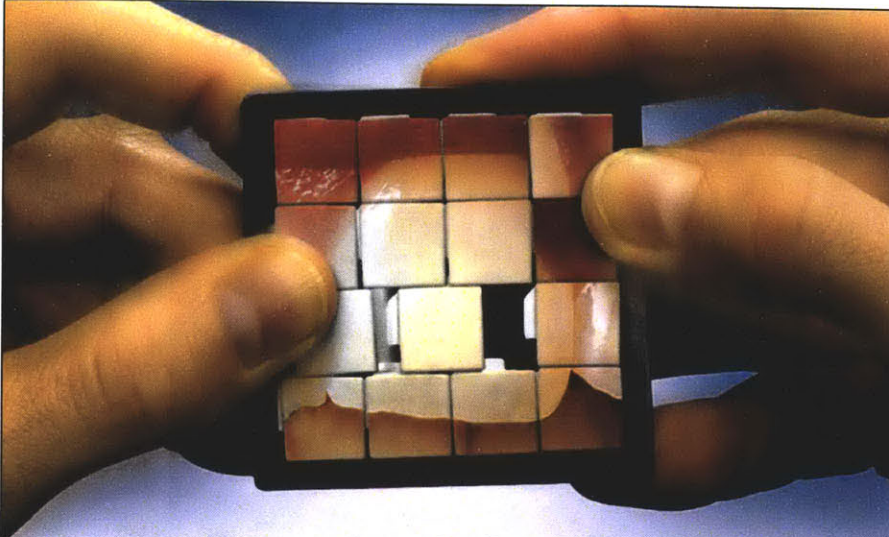







**Figure 6.2:** Model of HSL color space - similar to HSV color space - from Tectronix company's patent for an "Apparatus and Method for Modifying Displayed Color Images." The figure shown here depicts "an exploded view of a color model having hue, lightness, and saturation coordinates corresponding to selected ones of the modifiable color data." (from Gar A. Bergstedt, 1987, Apparatus and Method for Modifying Displayed Color Images, U.S. Patent no. 4,694,286, filed 8 Apr. 1983, and issued 15 Sept. 1987).





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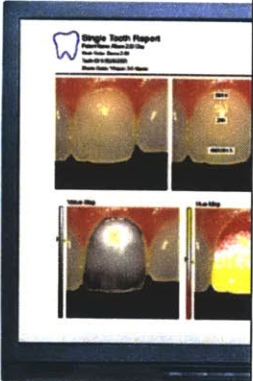
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Unlike digital cameras, ShadeVision provides a consistent, calibrated light source, which allows for the capture of true color information that cannot be derived from a photograph.

Using proprietary optics and filter technologies, ShadeVision creates precise color images that contain over 22,000 pixels of information. Its unique color analysis tool maps



The cordless, handheld ShadeVision instrument includes a touch screen display for unique "line of sight" viewing and precise positioning.

**Figure 6.3:** X-Rite's Shade Vision system is a dedicated cosmetic dentistry tool for matching tooth color. According to the company's brochure, this "analysis tool maps up to 50 regions of the tooth for three dimensions of color definition – value, hue and chroma." Not only does the tool cut down on "wasted chair time caused by unacceptable color matching" – with one pass of the tool, the patient's tooth data can be recorded and saved. Thus, "[t]he color accuracy of the restoration can be quality controlled in the lab without the presence of the patient" – an abstraction of color about which Bradley, Jeffries, and Munsell could only have dreamed.



# 1

## **Introduction: Talking about Color**

In 1973, two Danish Anthropologists, Rolf Kuschel and Torben Monberg, traveled to southern Pacific Ocean to study the relationship between language and color perception among the residents of Bellona Island – a society numbering roughly 800 people whose civilization had remained, as Kuschel and Monberg put it, “relatively untouched by European culture until approximately 1938 when the tenets of Christianity were introduced.”<sup>1</sup> The anthropologists’ goal was to ascertain how the Bellonese identified and classified colors – an inquiry which served as a window into the much larger anthropological and philosophical question of whether all people everywhere experienced reality in the same way, or whether differences in language, shared customs, and common frameworks for understanding the world actively shaped individuals’ perception of reality.

For several months, the anthropologists worked with a group of twenty-five adult informants, both men and women, presenting them with a number of different tasks designed to get to the root of their cognitive appreciation of color. In some

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<sup>1</sup> Rolf Kuschel and Torben Monberg, “‘We Don’t Talk Much About Colour Here’: A Study of Colour Semantics on Bellona Island,” *Man*, 9:2, June 1974, pp. 213-242, on pg. 214.

cases, the anthropologists simply asked their informants to verbalize their color sensations – to talk about what color terms they used, to indicate objects that corresponded to different terms, and to name the colors of objects selected by the anthropologists. In other instances, Kuschel and Monberg made use of an array of 329 “color chips” – cardboard squares used in psychometric research, each printed with a different, carefully calibrated, standardized color. In these cases, they would sometimes ask their subjects to group the colored chips into sets of like colors; other times, they placed the chips face-down on a cot, showing only their gray cardboard backs and asked their informants to flip the chips over one by one and name their color in Bellonese; in still other cases they arranged the color chips on a board in rough spectral order beneath a sheet of acetate and asked their subjects to draw lines in grease pencil on the acetate showing where one color category ended and another began. All of the Bellonese informants, moreover, were given color blindness tests to insure that their vision was not anomalous, either compared with their peers or with their anthropologist interlocutors.

Although Kuschel and Monberg found their informants to be “very conscientious in trying to fulfil [sic] [the] task in a way satisfactory to both themselves and to us” it was difficult for the anthropologists to compose a coherent picture of Bellonese color terminology.<sup>2</sup> For one thing, it was clear that their informants found the tests to be bewildering at best, tedious at worst. The task of categorizing hundreds of color chips, reported Kuschel and Monberg, “was as

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<sup>2</sup> *Ibid.* on pg. 328.

difficult, meaningless, and tiring to the Bellonese as it probably is to most of us.”<sup>3</sup> When their subjects joked that “white men always play like children,” the assessment generated agreement among onlookers.<sup>4</sup> For another thing, informants often found it difficult to understand that the colors of the color chips were supposed to represent the colors of everyday objects, and thought that their interlocutors wanted them to come up with individual abstract names for all three hundred of the colored squares – a fact that yielded an unusually “‘messy’ picture of [color] terms;” that is, one in which the same terms used by different observers did not consistently apply to basic categories of color in English, such as red, green, blue, etc. In some cases, words for color could even be strangely embarrassing: some informants said that the word commonly used for “white” or “light,” was *tea*, though others balked at the term – because, as Kuschel and Monberg explained, *tea* rhymed with the word *mea*, which connoted a reddish color associated with genitals.<sup>5</sup>

Finally, towards the end of the study, the anthropologists realized something that, upon reflection, the Bellonese had been trying to tell them all along: the Bellonese language contained many categories for naming and ordering objects and sensations, but color was not among them. As one informant explained, “‘[w]e do not have many colours; only three [...] And that’s all!’”<sup>6</sup> Another concurred, saying simply “we don’t talk much about color here.” Color, that is, was relatively

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<sup>3</sup> *Ibid.* on pg. 239.

<sup>4</sup> *Ibid.* on pg. 238.

<sup>5</sup> *Ibid.* on pg. 218. Kuschel and Monberg further explain that while *mea* connoted “redness” in many Polynesian languages, it was primarily used on Bellona “as one of the elements in invective speech.” As such some informants felt that *tea* – because of its close phonetic association with *mea* – could not be used “in the presence of one’s sibling of the opposite sex, or among in-laws of the same sex.” (223).

<sup>6</sup> *Ibid.* on pg. 218. The phrase “we don’t talk much about color here” does not appear in the text, but its use in the title – with accompanying single quotes – implies that an informant uttered it.

insignificant to the Bellonese as a perceptual, lexical and philosophical category. As such, the anthropologists concluded, tools such as standardized color arrays and color blindness tests were difficult to use with the Bellonese. It was not that they couldn't see color, but that the exercise of naming abstract colors was so alien as to be nonsensical. Color simply didn't have that kind of meaning on Bellona.

Looked at in one way, Kuschel and Monberg's study of the perceptual lives of the Bellonese – as well as other studies documenting chromatically-ambivalent societies such as the Hanunóo of the Philippines and the Zuni of the southwestern United States – provide a fascinating insight into the ways in which linguistic, cultural, and philosophical priorities might and might not shape perceptual reality.<sup>7</sup> Looked at another way, however, such studies beg a reciprocal question: why do Western anthropologists – and the wider societies of which they are a part – think of color the way that they do? By what logic do little squares of cardboard stand for colors in general? Why should some colors be able to be grouped and named by discrete units and not others, and what defines “basic” color terms? Why should it be possible – or even desirable – to separate normal from abnormal color vision, and what authority arbitrates the normal and the pathological? Indeed, what parameters define color as different from other visual datum (e.g. shininess, opacity, etc.) and why should we

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<sup>7</sup> On Hanunóo color categories see Harold C. Conklin, “Hanunóo Color Categories,” *Southwestern Journal of Anthropology*, 11:4, Winter 1955, pp. 339-344; on Zuni color terms see Eric H. Lenneberg and John M. Roberts, *The Language of Experience: a Study in Methodology* (Baltimore, Waverly Press, 1956). See also André von Wattenwyl and Heinrich Zollinger, “The Color Lexica of Two American Indian Languages, Quechi and Misquito: A Critical Contribution to the Application of the Whorf Thesis to Color Naming,” *International Journal of American Linguistics*, 44:1 Jan. 1978, pp. 56-68. C.f. Eleanor Rosch Heider, “Universals in Color Naming and Memory,” *Journal of Experimental Psychology*, 93:1, 1972, pp 10-20; and E. R. Heider and D.C. Oliver, “The Structure of Color Space in Naming and Memory for Two Languages,” *Cognitive Psychology*, Vol. 3, 1972, pp 337-354.



assume that color serves as a useful tool for thinking about the cognitive lives of other human beings?

This dissertation looks for the answers to these questions, not on Bellona Island, but in the place where many of these assumptions took their earliest and strongest forms – in the United States during the late nineteenth and early twentieth centuries. Unlike the Bellonese, Americans around the turn of the century talked about color constantly, obsessively, and, most of all, *scientifically*. They ruminated on how to use colors, and they bickered over the precise identity of particular colors. They worried about the consistency of sensations of color for different viewers, and they developed technologies for testing and reproducing color sensations across observers. They constructed elaborate extra-linguistic systems to differentiate colors; and rules for objectively defining and classifying color sensations. The debates, rules, technologies, and formal systems concocted by turn of the century Americans, moreover, were not simply the passing peculiarity of a bygone era – rather, they continue to underwrite the assumptions and understandings of color employed by Americans in the present day, from the use of color blindness tests in schools, to the design of color matching standards for commercial production and digital display, to scientific studies of cognition and perception. Indeed, the standardized color chips used by Kuschel and Monberg – so called “Munsell chips” – were the early twentieth century invention of Albert Munsell, a drawing professor at the Massachusetts Normal Art School in Boston who was obsessed with

scientifically defining the role of color in modern American society (see figure 1.1).<sup>8</sup> Munsell was just one of a great many American scientists, physicians, artists, educators, inventors, government regulators, and commercial manufacturers whose work on color re-shaped the perceptual worlds of Americans between 1831 and 1931.

Though an analysis of the history of color science in the United States between 1831 and 1931 I make three fundamental arguments. First, I argue that attempts to scientifically measure, define, and regulate color were not simply a matter of commercial utility, but were part of a wider program to construct a more rational, harmonious, and efficient American polity starting from one of the very baseline perceptual components of reality – the experience of color. As part of this program, I argue secondly that color science was as much a matter of prescription as description – that is, color scientists didn't simply endeavor to reveal the facts of perception and then graft them social problems, rather they wanted to train everyday citizens to *see* scientifically, and thereby create citizens whose eyes, bodies, and minds were both medically healthy and morally tuned to the needs of the modern American nation. Finally, I argue not only that perception has a history – i.e. that perceptual practices change over time, and that, at least for Americans of a century ago, experiences of color sensations were not taken as given but had to be laboriously crafted – but also that this history weighs heavily upon our present day

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<sup>8</sup> The idea of using Munsell chips was not Kuschel and Monberg's. Among the earliest uses of Munsell's colors in anthropological reports that I have found is Herbert J. Landar, Susan M. Ervin, and Arnold E. Horowitz's "Navaho Color Categories," (*Language*, 36:3 July-Sept 1960, pp. 368-382) in which the authors urge other investigators to follow their lead in using Munsell chips – indicating that, if not the first adopters of Munsell chips, as of 1960 the chips were not yet the standard mechanism for color testing in anthropology.

understanding of visual reality, as manifested not least of all in scientific studies of vision, language, and cognition.

The United States of the late nineteenth century was a nation in the grip of a profound series of industrial, cultural, and demographic crises. Between the end of the Civil War and the beginning of the twentieth century, industrial production and commercial trade in the United States skyrocketed. Huge increases in steel, coal, and factory production; tens of thousands of new track miles of railways; and a booming financial industry meant new ways of making money, new ways of organizing business and labor, and unprecedented forms of injury, death, and ruin.<sup>9</sup> The growing size and reach of large corporations and financial institutions eroded the traditional notion that America was a country of self-sufficient “island communities,” as people across the nation – rich and poor, urban and rural – found their lives and livelihoods increasingly enmeshed with those of labyrinthine bureaucracies in cities hundreds and sometimes thousands of miles away.<sup>10</sup> Following opportunities in urban centers, Americans left rural communities for

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<sup>9</sup> On the growth of railroads see, e.g. Alfred D. Chandler, *The Visible Hand: the Managerial Revolution in American Business* (Cambridge, Mass.: Belknap Press, 1977); on railroad accidents see Barbara Welke, *Recasting American Liberty: Gender, Race, Law and the Railroad Revolution, 1865-1920* (Cambridge: Cambridge University Press, 2001); Thomas J. Misa, *A Nation of Steel: the Making of Modern America, 1865-1925* (Baltimore: Johns Hopkins University Press, 1995); also David Montgomery, *The Fall of the House of Labor: the Workplace, the State, and American Labor Activism* (Cambridge: Cambridge University Press, 1987); on finance see, e.g. Robert Sobel, *The Big Board: a History of the New York Stock Market* (New York: the Free Press, 1965); on futures trading in particular see, e.g. William Cronon, *Nature's Metropolis: Chicago and the Great West* (New York: W.W. Norton and Company, 1991) pp 120-132. On failure as a concept in American life, see Scott A. Sandage, *Born Losers: A History of Failure in America* (Cambridge: Harvard University Press, 2005).

<sup>10</sup> Robert Wiebe coined the term “island communities” in *The Search for Order, 1877-1920* (New York, Hill and Wang, 1967). Alan Trachtenberg sketches a similar picture of island communities gradually being drawn together in *The Incorporation of America* (New York: Hill and Wang, 1982), while Cronon's *Nature's Metropolis* approaches the notion of increasingly interconnected American commercial, financial, and agricultural communities.

cities in ever-increasing numbers; the proportion of America's population that lived in cities rose from 6% in 1860 to almost 40% in 1900. A portion of this tremendous growth in urbanization and industrialization came from surges of immigrants from southern Europe, eastern Europe, and China – a demographic surge that provided new consumers and new sources of labor for American business, but who also brought with them new ways of life and, from the perspective of white elites, new problems of social order.<sup>11</sup>

Compounding these immediate dangers both to ways of life and physical being came more conceptual dangers as well. With the ostensible “closing of the frontier” in 1890, it seemed that the American landscape might no longer provide the crucible that had turned pioneering white, Anglo-Saxon Europeans into hearty, vital, Americans.<sup>12</sup> “Over-sentimentality, over-softness, in fact washiness and mushiness” were now the “great dangers of this age and of this people,” wrote Theodore Roosevelt in 1899.<sup>13</sup> Ironically enough, it seemed that the very civilization that white men had shed so much sweat and blood (though not always their own) to erect was sapping them of their vitality – and this at the exact moment that they had to contend with what was frequently perceived as an onslaught of millions of

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<sup>11</sup> See, e.g. Matthew Frye Jacobson, *Barbarian Virtues: the United States Encounters Foreign Peoples at Home and Abroad, 1876-1917* (New York: Hill and Wang, 2000). Nor was it just whites who worried about immigration and internal migration. For established minorities in Northern cities, new arrivals brought with them with strange customs and the worrying prospect of destabilizing the respect that they had worked hard to attain. For the reactions of Chicago's established black population at the turn of the century to the arrivals of large numbers of black migrants from the rural (and, sometimes, urban South), see James Grossman's masterful *Land of Hope: Chicago, Black Southerners, and the Great Migration* (Chicago: University of Chicago Press, 1989).

<sup>12</sup> Classic accounts of the pastoral myth in American culture include Leo Marx, *The Machine in the Garden: Technology and the Pastoral Ideal in America* (New York, Oxford University Press, 1964); and Richard Hofstadter, *The Age of Reform: From Bryan to F.D.R., 1916-1970* (New York: Knopf, 1955).

<sup>13</sup> Quoted in T.J. Jackson Lears, *Rebirth of a Nation: the Making of Modern America, 1877-1920* (New York: Harper, 2009) on pg. 37.

fecund, undisciplined, potentially uncivilizable immigrants – not to mention new additions to the extended American polity through the forced “civilization” of American Indians, and, after 1898, the annexation of the Philippines, Cuba, Hawaii, and Puerto Rico. Roosevelt’s dire warnings of “race suicide” in the face of impure, non-white “blood” was a premonition not just of the fate of the Anglo Saxon people, but of the country on the whole. Nor did the emerging culture of consumer marketing show much promise as a moral bulwark against the rising tide of decadence and decay. Beginning in earnest after the 1890s, manufacturers and retailers employed dazzling displays of color and light to whip consumers into frenzies of desire for manufactured goods – displays which were intended to, as one advertiser put it, “imprin[t] on the buying memory,” and appeal to “foreigners, children, people in every station of life.”<sup>14</sup> Nevertheless, as much as these displays might have struck some as a great aesthetic unifier, embracing all of America’s pluralistic population, others found the prurience and vulgarity of mass culture to be yet another sign of the dissolution of American cultural life.

In the face of these multiple, overlapping crises, both immediate and theoretical, Americans responded with an abundance of programs, institutions, and outlooks roundly summed up by historians under the unwieldy rubric of “Progressive” reform. As Glenda Elizabeth Gilmore points out, the term itself is an invitation to debate: Progressives have been characterized as agrarian and urban; economically elite and working-class; politically liberal and politically conservative; friends of workers and allies of big capital; top-down managers and grass-roots

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<sup>14</sup> Quoted in William T. Leach, *Land of Desire: Merchants, Power, and the Rise of a New American Culture* (New York: Pantheon, 1993) on pg. 45.

organizers.<sup>15</sup> By far and away the most common and wide-ranging characteristic of progressives, however, was a firm faith in the ability of science and rationality to pave the way to a brighter, more harmonious, more morally just future.<sup>16</sup> They looked to schemes of “scientific management” to provide the most unimpeachably fair work and pay schedules for workers and managers alike.<sup>17</sup> They read psychologist G. Stanley Hall’s treatises on human development and attempted to craft educational programs that would accommodate the natural development of the human beings to the norms of modern society.<sup>18</sup> Indeed, they invented the concept of “norms” to describe the scientific idea of what proper relationships among subjects of a modern, industrial nation should be like.<sup>19</sup> Even when they protested against the regimentation and weightlessness of a modern world dominated by science and technology – as did, for instance, the “antimodern” elites described in T.J. Jackson Lears’s *No Place of Grace* – they nevertheless placed their faith in the sciences of society as one means of finding a balance. Theirs was, in essence, an emerging managerial class, “not only earnest, but expert,” as W.E.B.

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<sup>15</sup> Glenda Elizabeth Gilmore and Richard Hofstadter’s edited volume *Who Were the Progressives?* (New York: Palgrave, 2002) provides an excellent overview of the contours of this debate.

<sup>16</sup> Wiebe’s *The Search for Order* provides the classic account of Progressive scientism. For an excellent updated perspective on how, precisely, science and rationality could combine in a vision of the future, see Jamie Pietruska, “Propheteering: a Cultural History of Prediction in the Gilded Age,” PhD Thesis, MIT, 2009.

<sup>17</sup> See, e.g. Robert Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency* (New York: Viking, 1997).

<sup>18</sup> See Gail Bederman, *Manliness and Civilization, a Cultural History of Gender and Race in the United States, 1880 to 1917* (Chicago: University of Chicago Press, 1995); also Robert L. Church, “Educational Psychology and Social Reform in the Progressive Era,” *History of Education Quarterly*, 11:4, Winter, 1971, pp. 390-405.

<sup>19</sup> See, e.g. James Mark Baldwin’s *Dictionary of Psychology and Psychiatry* (New York: the MacMillan Company, 1901), to which Charles Peirce contributed a definition for “norm.”

Dubois pithily put it, and profoundly confident of their ability to apply science to problems of industrial society.<sup>20</sup>

Research on color was, at its root, one of these programs in social reform. Not for nothing did the Munsell advertise his wares with the slogan “Color Anarchy is Replaced by Systematic Color Description.” Nor is it any coincidence that Walter Lippmann pointed approvingly to research on color blindness as an example of the sorts of scientific “mastery” over the human condition that he promoted in his 1914 *Drift and Mastery*.<sup>21</sup> The senses were understood as the bridge between objective reality and subjective thought – and none more so than vision, which in nineteenth century America retained its ancient philosophical association with reason and order. If it was possible to understand the innermost private sensations of individual subjects, then it would be possible to speak with the unimpeachable authority of scientific truth on all varieties of subjects of concern –the proper place of scientific authority in adjudicating matters of subjective judgment; the correct means of educating children to be morally healthy and aesthetically discerning citizens; the fundamental cognitive relationships between civilization and savagery. Color scientists envisioned their work as a protest against the vulgarity and uprootedness of American consumer culture, even as they ultimately threw their lot in with that very culture through tests designed to discipline the color vision of viewers; educational programs to teach people how to see, speak about, and consume color properly; and technologies to regulate color use for industrial

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<sup>20</sup> W.E.B. Dubois, *The Quest of the Silver Fleece* (Chicago: McClurg & Co., 1911) on pg. 299.

<sup>21</sup> Walter Lippmann, *Drift and Mastery: an Attempt to Diagnose the Current Unrest* (New York: Mitchell Kennerly, 1914) on pg. 273.

production and commercial manufacture. As such, their work can be seen as a quintessential progressive reform – at once authentic and artificial; forward-looking and deeply conservative; geared towards liberating the American citizenry through the imposition of moral and aesthetic order by experts.

Explaining the history of color science as a dynamic and nuanced set of responses to particular historical conditions is particularly important considering the prominent place that color has come to occupy, since its origins in the Progressive era, in disciplines as diverse as neuroscience, linguistics, psychology, sociology, philosophy and anthropology. Particularly since the last half of the twentieth century, color has served as the *sine qua non* of human mental experience – a model sensation upon which to base studies of language, cognition, and neurophysiology. As anthropologists John Lucy and Richard Schweder remarked in 1979, “research using color as a stimulus has produced what is perhaps the most cumulative and systematic corpus of basic data on the language and thought question” – a research project conducted under the “guiding assumption that the color spectrum was a continuum” and that “certain ‘focal’ areas in the color space are salient to the human perceptual system.”<sup>22</sup> Likewise, in 1999 psychologist Steven Engel reported on the “triumph of functional anatomy” engendered by research into color vision and brain function over the course of “40 years of research in the neurobiology of vision” – a program which again took a more or less universal notion of color perception as a given from which to generalize about

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<sup>22</sup> John A. Lucy; Richard A. Shweder, “Whorf and his Critics: Linguistic and Nonlinguistic Influences on Color Memory,” *American Anthropologist*, 81:3, Sept. 1979, pp. 581-615, on pg. 582.



neurobiology of human perception.<sup>23</sup> Indeed, in their popular text *Phantoms in the Brain: Probing the Mysteries of the Human Mind*, neurobiologist V.S. Ramachandran and journalist Sandra Blakeslee employ color perception as a sort of baseline test of the reality of all experience. Discussing the idea that vivid religious visions are caused by anomalous neural pathways in the limbic systems of ecstasies, Ramachandran and Blakeslee ruminate on the possibility that neuroscientific research might invalidate the existence of God (or, one supposes, gods). Their solution to answering this sticky question is to argue by analogy: “consider the fact that most animals don’t have the receptors or neural machinery for color vision. Only a privileged few do, yet would you want to conclude from this that color wasn’t real?” Certainly not, they decide.<sup>24</sup> In a very real way, for Ramachandran and Blakeslee, to see color is to experience the real – especially as the real meshes with contemporary biomedical understandings of human cognitive and affective function.<sup>25</sup>

This said, late twentieth century research on color perception sits on a foundation of deep historical disagreement – particularly within the American

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<sup>23</sup> Steven Engel, “Using Neuroimaging to Measure Mental Representations: Finding Color-Opponent Neurons in Visual Cortex,” *Current Directions in Psychological Science*, 8:1, Feb. 1999, pp. 23-27, on pg. 23.

<sup>24</sup> Vilayanur Subramanian Ramachandran and Sandra Blakeslee, *Phantoms in the Brain: Probing the Mysteries of the Human Mind* (New York: William Morrow and Company, 1998) on pg. 185. Stanley Finger likewise treats color vision as a central window into consciousness in his *Origins of Neuroscience: a History of Explorations into Brain Function* (London: Oxford University Press, 1994) on pp. 96-107.

<sup>25</sup> A 1992 conference at the Asilomar conference center in California brought together “visual scientists and psychologists with linguists and anthropologists” to discuss “key ideas, techniques and results from the study of color vision.” The results of the conference can be found in C.L. Hardin and Luisa Maffi’s edited volume *Color Categories in Thought and Language* (Cambridge: Cambridge University Press, 1992). The sixteen essays in the volume range in topic from the physiological – like Jules Davidoff’s “The Neurophysiology of Color” – to the historical, as with Ronald W. Casson’s “Color Shift: Evolution of English Color Terms from Brightness to Hue.”

anthropological and linguistics communities – over the degree to which perception is a function of cultural and language on the one hand, and biology on the other. This was, after all, precisely the problem that Kuschel and Monberg travelled to Bellona to study, and it was one with deep roots in American social science. On the one side, so-called “linguistic relativists” followed a long tradition in ethnolinguistics – beginning with Franz Boas in the 1890s and reaching its apotheosis in the work of linguist Benjamin Whorf in the 1950s – which saw language, cognition, and even sensory perception as fundamentally subject to the eddies and whorls of particular cultures.<sup>26</sup> Without a word for “green” in one’s language – subscribers to the most extreme version of linguistic relativism believed –one really could not be said to perceive the color green. On the other side, beginning in earnest in the 1950s, psychologists such as Eric Lenneberg at Harvard University and linguists such as Noam Chomsky at MIT began to formulate the theory of a “universal grammar” – that is, the notion that language is a product of particular neuro-physical features of the brain, and therefore not a product of culture at all, but rather of neurophysiology.<sup>27</sup>

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<sup>26</sup> The most famous exemplar of this outlook is in Benjamin Whorf, “The Relation of Habitual Thought and Behavior to Language,” in *Language, Thought and Reality*, (Cambridge: MIT Press, 1994) pp 134-159; see also Debi Roberson and Fatemeh Khosroshahi, “Penguins Don’t Care, but Women Do: A Social Identity Analysis of a Whorfian Problem,” *Language in Society*, 18:4, Dec. 1989, pp. 505-525; Ian Davies and Jules Davidoff, “Color categories are not Universal: Replications and New Evidence from a Stone-Age Culture,” *Journal of Experimental Psychology: General*, 129:3, Sept. 2000, 369-398. Guy Deutscher provides a somewhat more popular account of the relativist position in *Through the Language Glass: Why the World Looks Different in Other Languages* (New York: Metropolitan Books, 2010).

<sup>27</sup> See e.g. Noam Chomsky, *Syntactic Structures* (Gravenhage: Mouton, 1957); Noam Chomsky, *Aspects of the Theory of Syntax* (Cambridge: MIT Press, 1965), Eric H. Lenneberg, *Biological Foundations of Language* (Wiley: New York, 1967).

Against this backdrop, in 1969 anthropologist Brent Berlin and linguist Paul Kay released *Basic Color Terms* – a groundbreaking study of the ways in which human beings acquire words to describe abstract color sensations. Having tested subjects representing twenty language groups with Munsell chips, as well as drawing on previously-reported data from another seventy-eight languages, Berlin and Kay concluded that all natural languages add color terms in a fixed and invariable order: first, black and white; then red; then yellow *or* green; then yellow *and* green; then blue; then brown; and finally, in varying order, orange, purple, gray and pink. Berlin and Kay’s robust data on this seemingly invariable and cross-cultural order of color term acquisition seemed strongly to indicate that the foundation of color perceptions were, indeed, neurological and not cultural. As Berlin and Kay put it,

[t]he study of the biological foundations of the most peculiarly and exclusively human set of behavioral abilities – language – is just beginning [...] but sufficient evidence has already accumulated to show that such connections must exist for the linguistic realms of syntax and phonology. The findings reported here concerning the universality and evolution of basic color lexicon suggest that such connections are also to be found in the realm of semantics.<sup>28</sup>

Although *Basic Color Terms* did not put an end to the discussion – debate over the roots of color and language research continues to this day – Berlin and Kay and their like-minded peers did make a powerful impact on a broad range of fields dealing

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<sup>28</sup> Brent Berlin and Paul Kay, *Basic Color Terms* (Berkeley: University of California Press, 1969) on pp. 109-110.

with questions of cognition and perception. As psychologist Roger Brown put it in 1976, “[f]rom the extreme relativism of Whorf and the anthropologists of his day, we have come to an extreme cultural universality” of perception and language.<sup>29</sup>

The point of the present study is not to argue the veracity or illegitimacy of either linguistic relativism or universalism. Rather it is to point out that the very technologies and ideas used by contemporary scientists to study color perception – artifacts such as Munsell color chips, spinning color wheels, photometers, and even the very notion that some terms for color are “basic” while others are not – represent hard-won victories in a series of serious debates about the nature of color perception that occurred in the United States over a century ago. In order to properly understand what color *is* and how sensation relates to cognition and corporeal being, it is necessary to understand the nuanced and deeply contextual arguments and decisions that contributed to the design and understanding of perceptual technologies and theories of the present day.

In its broad outlines, of course, this notion – that any description of the senses, scientific or otherwise, must deal with historical and cultural specifics – is no longer as “scandalous” as Frederick Jameson suggested it might be in 1981.<sup>30</sup> In the past decade, both the *Journal of American History* and the *American Historical Review* have hosted forum discussions on the importance of histories and anthropologies of

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<sup>29</sup> Roger Brown, “In Memorial Tribute to Eric Lenneberg,” *Cognition*, Vol. 4, 1976, pp. 125-153, on pg. 149.

<sup>30</sup> See Frederic Jameson, *The Political Unconscious: Narrative as a Socially Symbolic Act* (Ithaca, NY: Cornell University Press, 1981) on pg. 229; Martin Jay makes the same point in his “In the Realm of the Senses: an Introduction,” *The American Historical Review*, 116:2, Apr. 2011, 307-315, on pg. 305.

the senses.<sup>31</sup> A dedicated journal, *The Senses and Society* has, since 2006, joined the ranks of edited volumes like *Sensing the Past: Seeing, Hearing, Smelling, Tasting, and Touching in History* (2007); *Sensorium: Embodied Experience, Technology, and Contemporary Art* (2006); *Empire of the Senses: the Sensual Culture Reader* (2005); and *Law and the Senses: Sensational Jurisprudence* (1996) in supplying detailed explorations of the senses in historical and cultural context.<sup>32</sup> Monographs devoted to historical and anthropological discussions of the five “traditional” senses – hearing, smell, taste, touch, and vision – likewise have become more plentiful in the past ten years: Emily Thompson’s *Soundscapes of Modernity* (2002) portrays attempts in late nineteenth and early twentieth century America to scientifically discipline sound through a variety of novel technologies; Alain Corbin’s seminal *the Foul and the Fragrant* (1986) describes olfaction and deodorization among French bourgeoisie in the late eighteenth and early nineteenth centuries; Paul Freedman’s *Out of the East: Spices and the Medieval Imagination* (2008) argues that the taste for spices among (principally wealthy) Europeans circa 1100 to 1400 was driven not by the utility of food preservation, but by the associations that spices cemented between gustatory pleasure, material wealth, and divine salvation; and as for touch, while the tactile has yet to garner sustained monographic attention, Constance Classen’s edited volume, *The Book of Touch*, and Elizabeth Harvey’s collection,

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<sup>31</sup> See, e.g. “AHR Forum: The Senses in History,” *The American Historical Review*, 116:2, Apr. 2011, pp. 307-401; also “The Senses in American History: A Round Table,” *Journal of American History*, 95:2, Sept. 2008, pp. 378-451.

<sup>32</sup> *Sensing the Past: Seeing, Hearing, Smelling, Tasting, and Touching in History*, ed. Mark M. Smith (Berkeley: University of California Press, 2007); *Sensorium: Embodied Experience, Technology, and Contemporary Art*, ed. Caroline Jones (Cambridge: MIT Press, 2006); *Empire of the Senses: the Sensual Culture Reader*, ed. David Howes (New York: Berg, 2005); *Law and the Senses: Sensational Jurisprudence*, ed. Lionel Bently and Leo Flynn (Chicago: Pluto Press, 1996).

*Sensible Flesh: On Touch in Early Modern Culture* (2003) both offer incisive essays on the myriad historical and cultural ways of thinking about touching (e.g. erotic; painful; comforting; informative) while Claudia Benthien's *Skin: On the Cultural Border between Self and World* (2002), and Steven Connor's *Book of Skin* (2004) investigate the social and cultural relationships between physicality, affect, and sensation as mediated by human beings' largest organs.<sup>33</sup>

Of all social-scientific research on the senses, studies of vision are inarguably the most plentiful – a fact that perhaps echoes the position of the visual as a seminal sensory object of neuroscientific and psychological study. As Martin Jay points out, the cultural study of vision can claim more than a dozen dedicated journals, including "*Journal of Visual Culture; Visual Studies; Invisible Culture: An Electronic Journal for Visual Culture; Early Popular Visual Culture; Visual Culture and Gender; See: A Journal of Visual Culture; Antennae: The Journal of Nature in Visual Culture; Visual Culture in Britain; Visual Anthropology; Visual Anthropology Review; Modernity: Critiques of Visual Culture; Muqarnas: An Annual on the Visual Cultures of the Islamic World; Visual Resources; Octopus: A Visual Studies Journal; and Contemporaneity: Historical Presence in Visual Culture.*"<sup>34</sup> Jay's own monograph, *Downcast Eyes: The Denigration of Vision in Twentieth-Century French Thought* (1993), traces ocularcentrism in French thought between the seventeenth and

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<sup>33</sup> Emily Thompson, *The Soundscape of Modernity: Architectural Acoustics and the Culture of Listening in America, 1900-1933* (Cambridge: MIT Press, 2002); Alain Corbin, *The Foul and the Fragrant: Odor and the French Social Imagination* (Cambridge: Harvard University Press, 1986); Paul Freedman, *Out of the East: Spices and the Medieval Imagination* (New Haven: Yale University Press, 2008); *The Book of Touch*, ed. Constance Classen (New York: Berg, 2005); *Sensible Flesh: On Touch in Early Modern Culture*, ed. Elizabeth Harvey, (Philadelphia: University of Pennsylvania Press, 2003); Claudia Benthien, *Skin: on the Cultural Border Between Self and the World* (New York : Columbia University Press, 2002); Steven Connor, *The Book of Skin* (Ithaca, NY: Cornell University Press, 2004).

<sup>34</sup> See Jay, "In the Realm of the Senses: an Introduction," on pg. 315 n. 24.

twentieth centuries, arguing that vision –prized as a central avenue to truth during the Enlightenment – gradually lost credibility among a line of twentieth century thinkers extending from Henri Bergson to Maurice Merleau Ponty.<sup>35</sup> Other scholars provide alternative analyses of the meanings of vision in different times and places. Jonathan Crary, for instance, treats technologies of vision and attention in Europe and the United States between the eighteenth and twentieth centuries in *Techniques of the Observer* (1993) and *Suspensions of Perception: Attention, Spectacle, and Modern Culture* (2000).<sup>36</sup> Caroline Jones writes about art critic Clement Greenberg's assiduous efforts to partition the senses for post-war American viewers in *Eyesight Alone: Clement Greenberg and the Bureaucratization of the Senses* (2005).<sup>37</sup> And Christopher Otter writes about the conjoined histories of gas lighting and surveillance in late nineteenth and early twentieth century Britain in *The Victorian Eye* – a study which explicitly takes up Michel Foucault's focus on vision as a source of social and political power.<sup>38</sup>

Within the sub-field of vision studies, moreover, color has concomitantly taken hold as something of a sub-sub field, demanding attention in much the same mode as the other senses. In 1978, art historian John Gage argued that, just as the

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<sup>35</sup> Martin Jay, *Downcast Eyes: the Denigration of Vision in Twentieth-century French Thought*, (Berkeley: University of California Press, 1993).

<sup>36</sup> Jonathan Crary, *Techniques of the Observer: on Vision and Modernity in the Nineteenth Century* (Cambridge, Mass.: MIT Press, 1990) and *Suspensions of Perception: Attention, Spectacle, and Modern Culture* (Cambridge, Mass: MIT Press, 1999).

<sup>37</sup> Caroline Jones, *Eyesight Alone: Clement Greenberg and the Bureaucratization of the Senses* (Chicago: University of Chicago Press, 2005).

<sup>38</sup> Chris Otter, *The Victorian Eye: A Political History of Light and Vision in Britain, 1800–1910* (Chicago: University of Chicago Press, 2008), and Michel Foucault, *Discipline and Punish* (New York: Vintage Books, 1995: 1977 1<sup>st</sup> English trans). Foucault elaborates on his discussion of power and vision particularly with respect to science in *The Order of Things* (New York: Routledge, 2002:1966). For analytical essays dealing with Foucault and visuality, see *Foucault and the Writing of History*, ed. Jan Goldstein (Cambridge: Harvard University Press, 1994).

senses-in-general can be historicized, “colour is not simply a sensible and measurable datum, but that, like space and physiognomy it has a history.” Scholars interested in explicating the formal characteristics of works of art, wrote Gage, needed to pay attention to this history, abandoning the “idea of the seamless coat of optical responses” in favor of the idea of variable responses at different times and in different cultures.<sup>39</sup> Perhaps ironically, Gage built his relativism on the work of Berlin and Kay, whose suggestion that black and white were the two most fundamental sensations Gage found useful for thinking about the sometimes-confusing color choices made by ancient and medieval artists, who favored juxtapositions between lightness and darkness over color harmonies. Gage reiterated his call for a relativistic approach to color in 1990, urging his fellow art historians to adopt a “broadly anthropological approach” to the study of color.<sup>40</sup> His subsequent texts, *Colour and Culture* (1999) and *Colour and Meaning* (1993) explain – in necessarily short and pithy sections – the dizzying range of material and cultural underpinnings of color in the visual cultures of the world from prehistory to the present day (while also, it should be noted, casting a somewhat more jaundiced

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<sup>39</sup> John Gage, “Colour in History: Relative and Absolute,” *Art History*, 1:1, March 1978, pp. 104 – 130, on pg. 104 and pg. 127.

<sup>40</sup> John Gage, “Color in Western Art: an Issue?” *The Art Bulletin*, 72:4, Dec. 1990, pp. 518-541, on pg. 539. As a later example of the sort of generalized thinking about color that Gage urged his readers to reject, consider, for instance, Amy Butler Greenfield’s *A perfect Red: Empire, Espionage and the Quest for the Color of Desire* (New York: Harper Perennial, 2005). Although it provides a useful general history of the cochineal trade across the Atlantic Ocean between the sixteenth and nineteenth centuries, Greenfield’s analysis runs aground on its initial claims that, firstly, “[a]s a species, [humans] prize color and attach great significance to it,” and secondly that “few colors mean as much to [humans] as red [...] Sacred to countless cultures, red has appeal to humans for time out of mind” (pp 1-2) – assertions which one might imagine alternately bemusing and scandalizing Kuschel and Monberg’s Bellonese informants.



eye on Berlin and Kay).<sup>41</sup> Gage's fellow art historian, Michele Pastoreau, similarly channeled his studies of the symbolism embedded in medieval heraldry into monographs on the meanings of the colors blue (2000) and black (2008) in European societies from "the beginning of the year 1000" to twenty-first century.<sup>42</sup> As with Gage, Pastoreau's approach offers short servings of evocative episodes in the histories of his topic colors, emphasizing in particular the many and changeable taboos and mores surrounding his topic colors. Other recent studies similarly attempt to reëncant both particular colors and color in general with more or less detailed accounts of the different methods, materials, and meanings of color as used in societies around the world and through history. Phillip Ball's *Bright Earth* (2001) for instance, provides a sensitive treatment of the many material cultures of color production in Europe and America since antiquity, while Simon Garfield's *Mauve* (2001) examines the social changes that accompanied (and fostered) the introduction of the novel purple dye and its variants into British society.<sup>43</sup>

And yet, the recent attention paid to the senses in general, and to color vision in particular, has yielded paradoxical results. On the one hand, scholars of the senses – particularly of the non-visual senses – routinely decry the overwhelming dominance of vision in scholarly work as a reason for accelerating social studies of other senses. Peter A. Coats's complaint that "historical studies in Europe and North

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<sup>41</sup> John Gage, *Colour and Culture: Practice and Meaning from Antiquity to Abstraction* (London: Thames and Hudson, 1993); and John Gage, *Color and Meaning: Art, Science, and Symbolism* (Berkeley: University of California Press, 1999).

<sup>42</sup> Michel Pastoreau, *Black: the History of a Color* (Princeton: Princeton University Press, 2009) on pg. 8; also *Blue: the History of a Color* (Princeton: Princeton University Press, 2001).

<sup>43</sup> Philip Ball, *Bright Earth: Art and the Invention of Color* (Chicago: University of Chicago Press, 2001); Simon Garfield, *Mauve: How One Man Invented a Color and Changed the World* (New York: Norton, 2001).

America, reflecting general trends within the humanities and social sciences and the dominant tendencies of our wider culture and society, have long been resolutely visual in their focus” is typical.<sup>44</sup> Mark M. Smith, likewise, writes that, “despite calls by linguists and theorists to end the privilege that sight enjoys over hearing, historians have only just begun to overcome their deafness to the aural worlds of the past.”<sup>45</sup> Moreover, some scholars interpret this “resolutely visual” focus not simply as evidence of an intellectual predilection, but as an indication of a hierarchy of the senses – one in which the dominance of vision attenuates the appreciation of other sensory experiences. In the introduction to his edited volume, *the Varieties of Sensory Experience*, for instance, anthropologist David Howes decries the “stultification” of smell, taste, touch, and hearing in the face of the “modern,” rational gaze, proposing that anthropological studies of non-visual senses in non-Western cultures might “help to *liberate* us from the hegemony which sight has for so long exercised over our own culture’s social, intellectual, and aesthetic life.”<sup>46</sup> In a similar vein, writing about the sense of smell, Constance Classen proposes that, in the modern world, “[i]t is not only the sense of smell that has lost ground against sight, of course, but all of the non-visual senses.”<sup>47</sup> Her 1998 book, *the Colour of Angels*, is an attempt to re-examine the visual in terms of other senses, which, she argues, have been sapped of their rich, social and metaphorical vitality by Western

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<sup>44</sup> Peter A. Coates. “The Strange Stillness of the Past: Toward an Environmental History of Sound and Noise.” *Environmental History*, 10:4, Nov. 2005, 636-635, on pg. 635.

<sup>45</sup> Mark M. Smith, “Listening to the Heard Worlds of Antebellum America,” in *the Auditory Culture Reader*, ed. Michael Bull and Les Back (New York: Berg, 2003) pp 137-163, on pg. 137.

<sup>46</sup> David Howes, “Introduction: ‘To Summon All the Senses,’” *The Varieties of Sensory Experience*, ed. David Howes (Toronto: University of Toronto Press, 1991) pp. 3-21, on pg. 4 and pg. 5.

<sup>47</sup> Constance Classen, *Worlds of Sense: Exploring the Senses in History and Across Cultures* (New York: Routledge, 1993) on pg. 15.

ocularcentrism.<sup>48</sup> Vision, in this scenario, is the best understood, the most utilized, and the most central sensation to our appreciation of the world around us.

At the same time, however, historians of color in particular have tended to characterize the modern understanding and experience of color vision not as a central portal through which modern people make meaning of the world around them, but as a seriously deficient mode of sensory apprehension. In this point of view, it is precisely because of its firm place as the ur-sensation of modernity – and particularly because of its position as a central subject of scientific research – that the experience of color has become so alienated from everyday life. At its most mild, this inclination expresses itself as a tendency to see color in science simply as an extension of commercial manufacturing – as, for instance, when historian of science Sean Johnston argues that color research at the turn of the century was “dominated by utilitarian need and pragmatic solutions” – an explanation which, without passing judgment on the place of vision in the hierarchy of sensations, characterizes the understanding of color less as a matter of probing the human condition than of mundane industrial efficiency.<sup>49</sup> Putting more of a point on the issue, Gage dismisses the broad swath of color science as a project of desensitization, complaining that “the aesthetics of colour have developed very little during this century [i.e. the twentieth] precisely because they have been too exclusively concerned with laboratory testing, and too little with colour preferences as expressed in the

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<sup>48</sup> Constance Classen, *The Colour of Angels: Cosmology, Gender, and the Aesthetic Imagination* (New York: Routledge, 1998).

<sup>49</sup> Sean Johnston, *A History of Light and Colour Measurement: Science in the Shadows* (Bristol, UK: Institute of Physics Publishing, 2001) on pg. 26.

practical choices of everyday life.”<sup>50</sup> In a similar vein, Ball writes that the usefulness of scientific systems such as Munsell’s are “limited by [their] attempt to impose scientific quantification on concepts of color that inevitably carry a lot of cultural baggage;” like Gage, Ball views color science as a process of divorcing the experience of color from whatever cultural or social meanings it might have for viewers.<sup>51</sup> Even anthropologist Michael Taussig, whose *Color of the Sacred* is otherwise a deeply sensitive exploration of the meanings of color across imperial power differentials in the nineteenth century, sees the engagement of science with the question of color perception as an essentially destructive encounter – one which “turned the senses against themselves so as to control them.”<sup>52</sup> Thus, while one group of scholars of the senses interpret vision as overwhelming both the lifeways of modern society and the academic studies of those lifeways, another group sees color – centrally among all sensory experiences – as dangerously attenuated vis-à-vis modern scientific culture.

It is, of course, difficult to deny the ostensibly privileged place of vision in modern society, nor do I dispute that the novel, scientific frameworks for thinking about color that emerged in the nineteenth century conflicted with older ways of understanding the senses. Indeed, the concerns voiced by twenty-first century social scientists about the dominance of vision had analogs in the early twentieth century. A 1912 book on primary education, for instance, cautioned that “[n]o organ is being strained more by the progress of civilization than the eye,” and the authors urged

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<sup>50</sup> John Gage, *Colour and Meaning*, on pg. 17.

<sup>51</sup> Ball, *Bright Earth*, on pg. 48.

<sup>52</sup> Michael Taussig, *What Color is the Sacred?* (Chicago: University of Chicago Press, 2009) on pg. 16.

educators to train their students' sense of touch as well as their eyes, lest "[t]he child who does not have this well-stored background of tactile-motor experience [become] the man who, though he has eyes, sees not."<sup>53</sup> At the same time, there is ample evidence that color scientists labored to change the ways that their fellow citizens thought about color. Semiotician and sometimes-color-scientist Charles S. Peirce, for example, insisted that, properly speaking, people experienced "color sensations" when they viewed the "colors" of objects – that is, "color" and "color sensations" were not the same thing; the worlds of subject and object were forever to be divorced if one wished to speak and think scientifically. In these instances – and others, to varying degree – one finds evidence both that vision could be seen as a privileged (or even over-privileged) form of meaning-making, and that the scientific understanding of color frequently necessitated a turn to novel ways of thinking about stimulus and sensation; object and subject.

This said, I do suggest, first, that for all of its apparent hegemonic dominance on modern experiences of the lived world, the priority of vision – particularly as an object of scientific study – didn't *weaken* the other senses, but simply drew them into different configurations, each of which yielded alternative understandings of sensation and the body generally. Certainly for the scientists, physicians, educators, and workers of the late nineteenth century, the scientific study of color necessitated a self-conscious deployment of many senses in unison. One need only look to, for instance, analogies between sound and vision discussed by experimentalists such as

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<sup>53</sup> Arnold Gesell and Beatrice Gesell, *The Normal child and Primary Education* (New York: Ginn and Co., 1912) on pp. 116-117.

Ogden Rood (ch 2) and A.H. Munsell (ch 5); or the emphasis on tactility in tests for color blindness conducted by B. Joy Jeffries (ch 3); or the equation made between heat and color by American steel workers (ch 5), to see several different modes of coordinated sensing taking place under the supposed domination of vision.

Moreover, throughout this study, my dramatis personae continually refer to very visceral notions of taste and touch – physiological explanations for disgust or fatigue in the presence of poor color combinations; the threat of real physical pain in the face of others – to emphasize the importance of their color work (see especially chapters 2 and 5). The meaningfulness of vision as a topic of scientific inquiry was, in these instances, based on the deployment of other senses. Nor were scientists alone in this conviction. An educator in 1908, writing about new pedagogical techniques explained that “[t]he usual public school methods have depended entirely on the child's learning through hearing. Now the other senses, those of sight and touch, are being used, and impressions made upon one sense are reinforced by the others.”<sup>54</sup> Far from dominating the other senses, or diluting their importance, increased attention to color vision as a topic of scientific, medical, industrial and pedagogical inquiry in modern America caused observers to rethink the relationships between all of the senses and the cogitating, feeling body as a whole.

Following from this suggestion, I secondly dispute the assumption that color science was a project of stripping social value or affective appreciation from visual experience in favor of anodyne industrial efficiency or abstract laboratory utility.

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<sup>54</sup> Florence N. Levy, “Educational Work of the Art Museums,” in *Art Education in the Public Schools of the United States*, ed. James Haney (New York: American Art Annual, Inc., 1908) on pp. 375-420, on pg. 382.

Rather, I take seriously the stance of anthropologist Anthony Seeger – as quoted by David Howes – that “[i]t is important to analyze how people think they perceive.”<sup>55</sup> For the individuals who populate the following pages, science was an important – and highly mutable – way of thinking about matters of perception alongside matters of morality, ethics, and aesthetics. The ways in which different groups manifested their feelings about thinking about perceiving – e.g. through measuring technologies, medical tests, lexicographic formalisms, color tables, and regulatory bodies to name a few – reveal a sensory landscape rich in multifaceted, vulnerable, and highly contested meanings of different sensory modes. To put it succinctly, American researchers did not simply erase the “cultural baggage” of perceptual meaning systems with “science” – rather, they leveraged science to make some cultural baggage of their own. If the vision science of the late nineteenth century seems like a bland, monolithic project, it is only because we scholars are not looking carefully enough.

In order to capture the ways in which theoretical concerns about the nature of color and everyday practices of color impacted and altered the lives of everyday Americans, I investigate a diverse base of sources, including the journals, letters and published works of scientists, critics and artists; medical reports and physicians’ case histories; catalogs issued by manufacturers of educational color material and industrial color standards; patents issued for color technologies; newspaper editorials; and, of course, the myriad colorful artifacts used to exemplify the proper comprehension of color, including color wheels, ribbons, paints, children’s

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<sup>55</sup> Howes, “To Summon All the Senses,” on pg. 3.

drawings, and color scales. I study scientists, of course, and not a few artists – but debates over color science also included teachers, railroad and steel workers, congressmen, doctors, commercial manufacturers, cigar rollers, government regulators, and local officials among a great many other people. Through a careful reading of the archival materials left by these and other actors, I hope to bridge the conceptual approaches to color that were espoused by a relatively few individuals – most of whom, as will be demonstrated, were in tight correspondence – with a new way of treating color as enacted across broad expanses of American life.

I follow these individuals through four topical and roughly chronological episodes, which make up the four principal chapters of this study. Chapter 2 examines the work of Ogden Rood (1831-1902), the first scientist in the United States to approach color as a topic of systematic scientific inquiry. His 1879 book, *Modern Chromatics*, had a profound impact on the ways in which a wide range of people – artists, scientists, linguists, physicians, among others – thought about color. Nevertheless, in spite of its reach, Rood’s text remains relatively unexamined in historical scholarship – mentioned as a strange and idiosyncratic outlier to proper color science when mentioned at all. This chapter argues that the recondite mixture of physics, physiology and aesthetics that underwrites Rood’s work is an attempt to negotiate a sphere of moral and aesthetic value between the highly sectarian religious science that dominated the United States in the first half of the nineteenth century, and the self-consciously rationalistic, disinterested – even atheistic – quantitative science of the second half. Color science, in this case, was part of a



larger argument during America's gilded age about what science ought to be able to say about human beings and human values.

In chapter 3, I document the emergence of research into color blindness in the late 1800s. During the same year as Rood released *Modern Chromatics*, Benjamin Joy Jeffries, a Boston ophthalmologist, published *Color Blindness: Its Detection and Dangers*. A little-studied scientific curiosity before the 1870s, color blindness emerged in the last decades of the nineteenth century as a serious threat to public health and safety, particularly since America's expanding industrial infrastructure required individuals who were able to read the color-coded signals of rail and ocean transports. Jeffries and his allies in academia, government, and industry advocated comprehensive programs of color blindness research and testing. Others, however, disputed Jeffries' claims – both his notions of what colorblindness was and how the colorblind saw the world; as well as his particular methods for testing sensations. I argue that the debate between Jeffries and his opponents was not just an argument about the subjectivity of color sensations, but one about expertise, authority, and power in the United States – an argument both about how people saw, and how people saw themselves and others in the Gilded Age United States.

Chapter 4 deals with the composition and definition of "basic" color terms. Among the most central – if most contentious – assumptions of modern studies of color and language is that the color vocabulary within a given culture's lexicon inevitably contains certain terms that are "basic" – that is, terms that simply refer to an abstract sensation of color. But what, precisely, color terms mean, and whether there are any "basic" sensations at all was a problem that preoccupied turn of the

century Americans, particularly in science and manufacturing. This chapter examines three attempts to develop systematic color vocabularies, each of which relied on very different notions of what color is, and how it ought to be spoken about. In the mid 1880s, Robert Ridgway, an ornithologist at the Smithsonian Institution, attempted to devise a scientific nomenclature of colors for use by naturalists, based on tables of color terms carefully, if ambiguously, keyed to objects. A decade later, John Henry Pillsbury, a high school botany teacher, and Milton Bradley, a printer and board game magnate, looked to the solar spectrum to introduce standard terms for color in education and manufacture. And between 1892 and 1929, Columbia University psychologist and logician Christine Ladd-Franklin mobilized color terms to argue for a unified theory of vision and mind. These works, I argue, offer three wildly different views as to what ought to constitute “basic color terms.”

In chapter 5, I return to Munsell and his color system. If attempts to compose natural language color vocabularies failed, another option was simply to manufacture a color system from scratch. This chapter examines the development of such a system by Alfred Munsell, a Boston art school professor and inventor, whose “Munsell color system” promised once and for all to regularize and standardize both the denotation and perception of color. Munsell promoted his system both as an industrial standard and as an educational aid. In effect, rather than attempting to discern the basis of color perceptions and encode them within a semantic system, Munsell endeavored to change the way that people saw and understood color to match his system. While he experienced a limited success in this endeavor in

education, he succeeded overwhelmingly in fitting his system into industrial, educational and scientific discourses that had been established over the preceding half century.

These four episodes reveal how the sustained attention of a wide range of Progressive reformers remade modern Americans' understandings of color from a conduit to religious truth in the middle of the nineteenth century to a subjective and abstract quality of psychophysics between the end of the Civil War and the middle of the twentieth century. The development of color-based psychophysics, color formalisms, color education programs and chromatic regulation initiatives reveals not a process of stripping moral and aesthetic value from human experience, but rather one of replacing one set of moral and aesthetic values with another, principally through debates about the nature of human beings in relation to their own internal senses and to each other. Differently put, color science in America in the late nineteenth and early twentieth centuries was not simply one of defining color, but of defining what kinds of people Americans were, and what sort of society they ought to construct. The lasting legacy of progressive era color science continues to this day, both in the technological artifacts of twenty-first century American visual culture; modern legal understandings of color and sensibility, and in assumptions underlying experimental "human sciences" which probe – not unlike their counterparts a century ago – the nature of human beings vis-à-vis their sense of color.



## 2

### **American Psychophysicist: Ogden Rood and the Origins of Color Science in America**

#### Introduction

Scientists in the United States in the first half of the nineteenth century tended not to see color as an especially important, interesting or viable subject for scientific inquiry. In magazines and journals, popular writers rhapsodized on the meanings of different colors in spiritual life or discussed color in decoration and clothing.<sup>1</sup> Physicians occasionally wrote short, speculative pieces on color and ocular health.<sup>2</sup> And color was, of course, a central topic of discussion among artists, decorators and designers, in which science sometimes made a useful foil for thinking through aesthetic matters. In 1856, for example, *The Crayon*, a New York based magazine “devoted to the graphic arts and the literature related to them” translated an essay by Swiss chemist Raoul Pictet entitled, “The Beautiful in Inorganic Nature and in the Vegetable Kingdom,” which dealt with color form and harmony in nature.<sup>3</sup> But establishment American scientists in the 1830s, ‘40s and ‘50s by and large steered

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<sup>1</sup> For a treatment of the meanings of color, particularly with regard to emotions, see “The Philosophy of Colours,” *Knickerbocker; or New York Monthly Magazine* 3:3, March 1834, 218 – 222; for color in dress see “On the Harmony of Colors in its Application to Ladies’ Dress. By Mrs. Merrifield,” *Peterson’s Magazine*. 22:2, August 1852, on pg. 106.

<sup>2</sup> See, e.g. “The Effect of Color upon Health,” *Scientific American* 11:47, August 2, 1856, on pg. 345; reprinted in *the Churchman’s Monthly Magazine*, IV:6, June 1857, 374-375; also Edward Reynolds, *Hints to Students on the Use of the Eyes* (Edinburgh: Thomas Clark, 1835).

<sup>3</sup> Raoul Pictet, “The Beautiful in Inorganic Nature and the Vegetable Kingdom,” *The Crayon*, 3:7, Dec. 1856, pp. 363-365.

clear of the systematic study of vision in general, and color in particular. Studies of the senses, noted the venerable American scientist, Joseph Henry, in 1860, were in the main “disappointing” because they contained “a good deal of indefinite speculation [...] but little positive knowledge.”<sup>4</sup>

Between the beginning of the Civil War and the end of the nineteenth century, however, the attitude of American scientists towards sciences of the senses – and of color in particular – shifted dramatically. If Henry could dismiss the paucity of knowledge about the senses in 1860, thirty five years later, LeConte Stevens, keynote speaker at the physics section of the 1895 meeting of the American Association for the Advancement of Science, singled out optics – including physiological optics and research into color vision – as the area of physics in which Americans could claim to have made the greatest contributions to world science. As he put it to his audience of researchers,

“with full recognition of the greater spread of devotion to pure science in Europe, of the extreme utilitarian spirit that causes the value of nearly every piece of work in America to be measured in dollars, we are still able to present work [in optics] that has challenged the admiration of Europe, that has brought European medals to American hands, that has been done with absolute disregard of monetary standards; work that has been recognized,

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<sup>4</sup> Joseph Henry to Rood, 18 Jun. 1860, Box 1, Folder: Henry, Rood Family Papers, MS#1082, Rare Books and Manuscript Library, Columbia University.

even more in Europe than in America, as producing definite and important additions to the sum of human knowledge.”<sup>5</sup>

The present chapter examines the origins of these “additions to the sum of human knowledge,” arguing that interest in color as a topic for scientific research in the United States was, in large part, a practical reaction to an epistemological crisis within the establishment science of the previous decades. In the elite, sectarian world of antebellum science, knowledge was largely understood as a product of one-to-one correspondence between sensation, reality and divine truth. Science in this sense was an agreed-upon mode of organizing the empirical knowledge gleaned from sensory experience into laws of nature that were beautiful, true, and morally right. This notion of science and sensation as revelatory of moral truths collapsed decisively in the middle of the century amid the chaos of warfare and industrialization; against the pressure of a rising, non-denominational, professional science; and – most importantly – through the course of debates about the relationship between sense perception, scientific knowledge, and moral values in modern America. The color science that emerged in its place was an attempt to make perception into a viable object of scientific inquiry while still preserving its traditional value as a stabilizing site of empirical and moral truth.

These changes in the relationship between sense perception, scientific knowledge, and the meaning of lived experience emerge especially clearly in the work of Ogden Rood, a physicist at Columbia College from 1863 to 1902. Rood was

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<sup>5</sup> LeConte Stevens, “Recent Progress in Optics,” in *Proceedings of the American Association for the Advancement of Science for the Forty Fourth Meeting held at Springfield, Mass, August-September, 1895* (Salem: Published by the Permanent Secretary, 1896) pp 33-54, on pg. 34.

among the first American scientists to devote sustained and systematic attention to the senses in general, and color in particular. His 1879 *Modern Chromatics, with Applications to Art and Industry* was the first American book on color science, and, through six re-printings over the course of a century, became a foundational text for Americans' understandings of their own sensual worlds.

Rood, himself a serious amateur painter, made it clear that he had written *Modern Chromatics* in order to “prevent ordinary persons, critics, and even painters, from talking and writing about colour in a loose, inaccurate and not always rational manner.”<sup>6</sup> And in this, he succeeded, at least insofar as Rood's book changed the ways that people spoke about, wrote about, and used color. Ophthalmologists and photographers, architects and educators, professional artists and hobbyist decorators all read *Modern Chromatics*. Louis Sullivan reached for the book when he designed the interior of the Chicago Stock Exchange in 1893; Classicist Edward Hopkins pointed his readers towards *Modern Chromatics* to explicate the complicated nature of the term “indigo.” Outside of the United States, the group of painters in France who called themselves “neo-impressionists” attempted to radically change the production and viewing of paintings through, as painter Camille Pissarro put it, a “modern synthesis of methods based on science, that is, based on M. Chevreul's theory of color and on the experiments of Maxwell and the measurements of O.N. Rood.”<sup>7</sup>

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<sup>6</sup> Ogden Rood, *Modern Chromatics, with Applications to Art and Industry* (New York: D. Appleton and Company, 1879) on pp. v – vi.

<sup>7</sup> On Sullivan and Rood, see Lauren S. Weingarden, “The Colors of Nature: Louis Sullivan's Architectural Polychromy and Nineteenth-Century Color Theory,” *Winterthur Portfolio*, 20: 4, Winter, 1985, pp. 243-260 and William W. Braham, “Solidity of the Mask: Color Contrasts in Modern Architecture,” *RES: Anthropology and Aesthetics*, Spring, 2001, pp. 192-214; for Rood's use among



A close focus on Rood's work vis-à-vis the shifting social, cultural and material contingencies of scientific practice in the nineteenth century yields a finely grained and locally specific story about the nature of the relationships between sciences and senses. This story will proceed in three parts. Part one will examine what perception meant to the scientific establishment in which Rood first began to consider questions of color. Part two will trace dramatic moves in the political, social and moral values of science in the middle of the century. And the final section will detail Rood's synthesis of these changes in sensing and knowing into an ostensibly comprehensive – though controversial – text on the nature of color for the modern observer. A close focus on Rood will therefore facilitate more than just a detailed analysis of a key player in American color science; it will also reveal American color science as a practice not simply of measuring perception, but also as a mode through which a rapidly changing society could potentially adjudicate matters of beauty, truth, and moral and spiritual rectitude.

### Doxological Science

The scientific world of the early nineteenth century US is not infrequently characterized as an intellectual doldrums – a national culture of pious practicality rather than inspired ratiocination; a land of searchers with the souls of shopkeepers.<sup>8</sup> If in the early days of the nation, Enlightenment idealism, natural

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classicists see Edward W. Hopkins, "Words for Color in the Rig Veda," *The American Journal of Philology*, 1 Apr 1883, pp 166 – 192, on p 179; Pissarro quoted in Phoebe Pool, *Impressionism* (New York: Praeger, 1967) on pp 243-244.

<sup>8</sup> See, for instance, George H. Daniels, *American Science in the Age of Jackson* (New York: Columbia University Press, 1968); and Daniels, *Science in American Society: a Social History* (New York: Knopf, 1971); Sally Gregory Kohlstedt, *The Formation of the American Scientific Community: the American*

science, and religious conviction had seemed to walk hand-in-hand towards the ultimate perfection of humankind, by the early 1800s the reputation of science as a harmonious organizing principle for civil life was in steep decline. The French revolution had revealed the sanguinary underbelly of the Age of Reason, and Americans reacted strongly. “Among Western Christians,” writes historian T.D. Bozeman, “the terrible scenes of chaos and gore enacted in the years following 1789 evoked wholesale fright” – as well as a firm push away from Enlightenment skepticism that involved, not least of all, “the potent antidote of [religious] revivalism.”<sup>9</sup> In this environment, the narrative continues, a sort of anti-science thrived – Americans were keen on technological innovations and rough-and-ready tinkering, but were markedly less excited about attempting to build an ideological platform based on rational skepticism upon which to formulate universal truths.<sup>10</sup>

Nevertheless, scholars such as Bozeman have detected amid the reactionary evangelism of the 1800s a strong ideological movement that attempted, in spite of the reverberations of *la Terreur*, to craft a celebratory science that would be both

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*Association for the Advancement of Science, 1848-60* (Urbana : University of Illinois Press, 1976); Robert V. Bruce, *the Launching of American Science, 1846-1876* (Ithaca, NY: Cornell University Press, 1987); *Technical knowledge in American Culture: Science, Technology, and Medicine Since the Early 1800s*, ed. Hamilton Cravens, Alan I. Marcus, and David M. Katzman, (Tuscaloosa: University of Alabama Press, 1996); James Delbourgo, *A Most Amazing Scene of Wonders: Electricity and Enlightenment in early America* (Cambridge: Harvard University Press, 2006); Martin Richard Clagett, *Scientific Jefferson Revealed* (Charlottesville, Va.: University of Virginia Press, 2009).

<sup>9</sup> Theodore Dwight Bozeman, *Protestants in an Age of Science: The Baconian Ideal and Antebellum American Religious Thought* (Chapel Hill: University of North Carolina Press, 1977) on pg. 46.

<sup>10</sup> Several scholarly works have been published in recent years detailing different aspects of the epistemological jockeying between science and religion in the United States in the nineteenth century. See, e.g. William J. Astor, *Observing God: Thomas Dick, Evangelicalism, and Popular Science in Victorian Britain and America* (Burlington, Vt.: Ashgate, 2001); Phillip E. Johnson, *The Wedge of Truth: Splitting the Foundations of Naturalism* (Downers Grove, Il: InterVarsity Press, 2000); Paul Jerome Croce, *Science and Religion in the Era of William James* (Chapel Hill: University of North Carolina Press, 1995). The classic text on the subject is Herbert Hovenkamp, *Science and Religion in America, 1800-1860* (Philadelphia: University of Pennsylvania Press, 1978).

intellectually coherent and compatible with Christian theology. Bozeman calls this practice “doxological science” – a term which captures at once the sense of felicity and celebration that practitioners brought to their investigations. Among the most influential boosters of doxological science in the early nineteenth century were “Old School” Presbyterians – conservative Presbyterians who held an overwhelming amount of power among intellectual elites in American society.<sup>11</sup> Centered in Princeton and Yale, and writing in organs like *The Princeton Review*, Presbyterian scholars such as Princeton principal Charles Hodge, philosopher Samuel Tyler, and scientists like Joseph Henry, Benjamin Silliman and James Dwight Dana made the case for the importance to the developing nation not only of science, but of the cultivation of scientific experts – individuals specially trained in skills of observation and precision measurement. For these individuals, scientific work was both practical and morally uplifting. It could, of course, serve the needs of commerce and industry, and provide a great source of wealth for the nation, through applications in cartography, navigation, engineering, agriculture and so forth. But more than that, science offered a source of moral uplift. Far from being anti-God, or Godless, argued

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<sup>11</sup> The term “old school” comes from a schism that emerged in 1837 over the nature of Presbyterian government. In essence, Presbyterian church governance tended to be either centrally organized into presbyteries or locally organized into congregations. Tensions in these two forms of government – exacerbated by ecclesiastical differences and in the rapid expansion of the church by evangelicals – led to a split; the “old school” faction tended to favor centralized governance, the “new school” faction a more decentralized form – although in practice a further, somewhat later split, occurred between northern and southern churches over the issue of slavery. Even with such internecine tension, however, Presbyterian centers like Princeton Seminary in the north, and the University of Virginia and the University of South Carolina in the south nevertheless maintained a vigorous exchange of people and ideas. See, e.g. *The Pluralistic Vision: Presbyterians and Mainstream Protestant Education and Leadership*, ed. Milton J. Coalter, John M. Mulder, and Louis Weeks (Louisville, KY: Westminster/John Knox Press, 1992); for an account more contemporary with the schism see Henry Woods, *The History of the Presbyterian Controversy: with Early Sketches of Presbyterianism* (Louisville, KY: N.H. White, 1843); Mark Noll writes about the central role of Princeton as a hub of Presbyterianism in *Princeton and the Republic, 1768-1822: the Search for a Christian Enlightenment in the Era of Samuel Stanhope Smith* (Princeton, N.J.: Princeton University Press, 1989).

these commentators, science could serve as an avenue to communion with God, provided the scientists disciplined themselves to follow strict mental and moral procedures.

Though different thinkers offered different glosses on the particulars of scientific practice, the general argument floated repeatedly by *Princeton* reviewers and other conservative Presbyterian philosophers of science went like this: science is principally an action of ordering the facts of nature. Facts are gained through observation of the natural world. A mature, freethinking, self-reflective intellect can structure these facts to display what Hodge called their “internal relations.”<sup>12</sup> Through these internal relations, properly evaluated, one could begin to see a divine hand underwriting the ordered complexity of the natural world. Science, seen in this distinctly Calvinist light, was an activity of works that *revealed* nature – of human action – rather than one of passive revelation; it was an activity of moral introspection rather than extroversion. And if in the end, it was ultimately expected that the word of God written through science would harmonize with the word of God written in the bible, Biblical hermeneutics was a flexible endeavor, and scientific work was well adapted for envisioning His works in all creation.<sup>13</sup>

Or, at least, almost all creation. If mainstream Presbyterian philosophers of science welcomed scientific inquiry into astronomy, geology, natural history, and the fundamentals of the physical forces and the chemical elements, they looked

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<sup>12</sup> Charles Hodge, *Systematic Theology* (New York: Scribner, Armstrong and Co., 1873) on pg. 1.

<sup>13</sup> The notion of detecting an authorial presence at work in the natural world did not dim with the waning of religious presence from scientific life. Lily E. Kay, for instance, documents the persistence of an allegorical author in the practice of modern genetics in *Who Wrote the Book of Life?: A History of the Genetic Code* (Stanford CA: Stanford University Press, 2000).

much more skeptically upon humans as a subject of science – not so much in terms of gross anatomy or physiology, but in terms of sciences of the mind, of the senses, of society. Across the Atlantic ocean, in the early part of the century, German scientists such as Ernst Weber, Johannes Müller, and Gustave Fechner had inaugurated the field of “psychophysics” – the study of the relationship between physical stimuli and subjective sensation – with studies such as Müller’s *Zur Vergleichenden Physiologie des Gesichtssinns* (*Physiology of the Senses*; 1826) and Fechner’s later *Elemente der Psychophysik* (1860). In France, the famed chemist Michel Eugen Chevrueil had published his *De la loi du Contraste Simultané des Couleurs et de l’assortiment des Objets Colorés* (1839), (translated as *Principles of Harmony and Contrast of Colours* in 1854), which described the ways in which different objective colors “mixed” in the eye to create entirely different chromatic sensations. And in Britain in 1810, Thomas Young developed the theory – later augmented by James Clerk Maxwell and, still later, Hermann von Helmholtz – that all color perception was a result of retinal mixes of red, blue and green stimuli.<sup>14</sup>

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<sup>14</sup> Works on Young, Helmholtz, and Maxwell’s theories of light and color are manifold. Of the three scientists, Helmholtz has attracted the most sustained attention and prompted the most interesting historical work. See, e.g. Timothy Lenoir on Helmholtz’s physiological optics vis-à-vis those of his mentor, Müller, and the philosophy of Emanuel Kant in “The Eye as Mathematician: Clinical Practice, Instrumentation, and Helmholtz’s Construction of an Empiricist Theory of Vision,” in *Hermann von Helmholtz and the Foundations of Nineteenth-Century Science*, ed. David Cahan (Berkeley: University of California Press, 1993) pp. 109-153; Steven Turner applies a social studies of science “conflict studies” approach to examining disputes between Helmholtz and Ewald Hering over the fundamental hues of human color vision in *In the Eye’s Mind: Vision and the Helmholtz-Hering Controversy* (Princeton: Princeton University Press, 1994); David Cahan gives specific and detailed accounts of Helmholtz’s influence in the United States – though not specifically related to optics – in “Helmholtz and the Shaping of the American Physics Elite in the Gilded Age,” *Historical Studies in the Physical and Biological Sciences*, 35:1, September 2004, 1–34; see also Cahan’s “Helmholtz in Gilded-Age America: the International Electrical Congress of 1893 and the Relations of Science and Technology,” *Annals of Science*, 67:1, January, 2010, pp 1-38. A serviceable take on the three scientist’s work can be found in Paul D. Sherman, *Colour Vision in the Nineteenth Century: the Young-Helmholtz-Maxwell Theory* (Philadelphia: A. Hilger, 1981). Likewise, Selig Hecht provides a reasonable account of Young’s theory of color in “The Development of Thomas Young’s Theory of Color Vision,” in *the Journal of the Optical*

American scientists kept abreast of these developments, but tended at best to receive them without much excitement. Joseph Henry, of course, had expressed disappointment in psychophysics in general, and had singled out Müller for particular criticism. Oliver Wolcott Gibbs, a young chemist and friend of Rood's, used Chevreul's color charts in his own work on ammonia-cobalt salts, appending the lukewarm comment that the charts "appear to be reliable; in any event they give *some* precision to determinations of color."<sup>15</sup> It would be 1876 before William James set up the United States' first psychophysics laboratory (only to abandon it shortly thereafter, having recruited the German psychologist Hugo Munsterberg to run it) – and even then, James cast a dim view on his forbears writing, "[i]t is more than doubtful whether Fechner's 'psychophysic law' [...] is of any great *psychological* importance, and we strongly suspect that Helmholtz's 'unconscious inferences' are not the last word of wisdom in the study of perception."<sup>16</sup> Indeed, as late as 1907, Alfred Munsell, a psychophysics-minded color theorist from Boston would shock an audience of art educators in Cleveland by insisting that it was the eye – and not pigment – that really had the most sway over how human beings perceived color. Research into the fundamental workings of the color sense was not on the menu of nineteenth century American science.

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*Society of America*, 20:5, 1930 pp 231-270. At least as far as his contributions to color theory specifically, Maxwell seems to be the least studied of the trio. See C. W. Francis Everitt's *James Clerk Maxwell: Physicist and Natural Philosopher* (New York: Scribner, 1975) for a fine biography; chapter five deals with color. Maxwell gets a brief mention in Edwin G. Boring, *Sensation and Perception in the History of Experimental Psychology* (New York: Appleton-Century Company Incorporated, 1942) pp. 185-186.

<sup>15</sup> Wolcott Gibbs and F.A. Genth, "Researches on the Ammonia-cobalt Bases," *Am. J. Science and Arts*, XXIII:63, March 1857, pp 234 – 265, on pg. 237. Emphasis in original.

<sup>16</sup> William James (unsigned essay), "The Teaching of Philosophy in our Colleges," *The Nation*, XXIII, 21 September, 1876. Walter Robert Corti credits Ralph Barton Perry with the attribution of the essay to James in his *The Philosophy of William James* (Hamburg: Felix Meiner, 1976) on pg. 279.

Part of the reason for the early disinterest in psychophysics – including the psychophysics of color – was perhaps a lack of immediate applications. As historian Sally Gregory Kohlstedt remarks, “[a] steady stream of inventions in the new nation brought more applause for utilitarian applications of science than for less easily understood European advances in laboratory research.”<sup>17</sup> Chevrueil had formulated his theories of color and perception while overseeing Gobelins tapestry works in Paris, which at the time was responsible for executing vivid carpets and wall hangings for France’s Bourbon rulers. Lacking an exacting royal clientele, it is possible that there was less impetus on American scientists and manufacturers to address questions of color perception. Likewise, pigments for dying and painting were still primarily imported from Europe, or else manufactured on smaller scale by artisans who didn’t easily divulge their secrets – so it is possible that practical applications of a color science were not felt as strongly in the United States as in Europe.<sup>18</sup>

More importantly, the relationship between the (literal) matter of science, the sense of vision, and the experience of the divine did not, for orthodox scientists, invite scientific analysis. This was emphatically not, however, because vision was taken for granted by the conservative Presbyterians who held dominant sway in nineteenth century academic science, but rather the opposite: the sense of vision was critical to the formula by which scientific research could coexist with a belief in

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<sup>17</sup> Sally Gregory Kohlstedt, *The Formation of the American Scientific Community: The American Association for the Advancement of Science* (Chicago: University of Illinois Press, 1976) on pg. 2.

<sup>18</sup> On artists’ pigments see, Rutherford J. Gettens and George L. Stout, *Painting Materials: A Short Encyclopedia* (New York: Dover Publications, 1966); *Artists’ Pigments: A Handbook of Their History and Characteristics*, ed. Robert L. Feller (Washington, D.C.: National Gallery of Art, 1986); and Alexander W. Katlan, *American Artists’ Materials Suppliers Directory: Nineteenth-Century* (Park Ridge, N.J.: Noyes Press, 1987).

God. The senses were seen as the conduits of basic, objective facts about the world – indeed, the very idea of a “fact” was synonymous with the experience of external reality.<sup>19</sup> Others might argue that sensory experience was an order removed from the actual nature of matter in the world, as when British writer George A.M. Payne declaimed upon the difficulty of ridding “ourselves of the belief that something analogous to our sensations of colour is inherent in bodies!” Nevertheless, Payne insisted, “colour, as a quality of *the rays themselves*, is nothing more than an aptitude, of the nature of which we can know nothing, to excite certain sensations in our minds.”<sup>20</sup> In the face of such analysis (even if it did bear the latent imprimatur of Newton) the *Princeton Review* was unimpressed. “We have always thought that we acquire our knowledge of external objects by perception,” wrote *the Review* in response to Payne. “To make known to us the existence of matter and its qualities is precisely what our senses were *given us for* [...] All that we can affirm from experience is, that from our earliest recollection, our senses have contributed to increase the extent and accuracy of our knowledge of matter.”<sup>21</sup> The senses were trustworthy, basic – essential to understanding the world through science. As a writer in the *American Journal of Science and Arts* put it, “yellow” was yellow, and “sour” was sour – these were fundamental qualities that transcended deep inspection.<sup>22</sup>

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<sup>19</sup> Bozeman, *Protestants in an Age of Science*, on pg. 55.

<sup>20</sup> George A.M. Payne, *Elements of Mental and Moral Science* (London: B.J. Holdsworth, 1828) on pg. 77.

<sup>21</sup> Review of *Elements of Mental and Moral Science* by George A.m. Payne, *The Princeton Review*, 2:2, April, 1830, pp. 183-210, on pg. 196.

<sup>22</sup> J.D. Whelpley, “Letter on Philosophical Induction,” *American Journal of Science and Arts*, Jan. 1848, on pg. 34.



Indeed, beyond simply providing objective data about the world, for scholars like those who wrote for the *Princeton Review*, the senses were critical to stimulating the sort of aesthetic experience that underwrote belief in a generous and omnipresent creator. “The Power [sic] and wisdom of God appear in so forming the eye and adapting it to the element of light as to make us capable of vision,” wrote one commentator, “but His benevolence is manifested in adorning the earth with such scenes of majesty and beauty as minister delight to every beholder.”<sup>23</sup> Moreover, the reviewer continued, if the world was made – and made beautiful – in order to be seen, scientific investigation held the key to yet greater evidence of the divine hand underwriting natural order, for “[e]ven when examined by a microscope [...] [n]o flaw can be found in the minutest works of God; but on the contrary, on the closest inspection they exhibit beauties unsuspected before.”<sup>24</sup> The appreciation of beauty – even (perhaps *especially*) through the senses augmented by scientific apparatus – was imperative to the realization of divinity underwriting nature.

As such, in its most aggressive form, a science that purported to examine the material underpinnings of the human senses – and, indeed, cognition of those senses – met with vigorous opposition from the most conscientious Presbyterian thinkers. Nowhere is this more clearly seen than in the reaction of Presbyterian philosophers to August Comte and his positivism. If Fechner, Wundt, et al, elicited little but shrugs from establishment scientists in the United States (at least early in the century),

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<sup>23</sup> “Moral Aesthetics; or the Goodness of God in the Ornaments of the Universe,” *Princeton Review*, 24:1, Jan. 1852, 38-52, on pg. 38.

<sup>24</sup> *Ibid.* on pg. 42.

their theologically astute peers greeted Comte with shrieks of protest. The horrors of positivism didn't begin or end with Comte's insistence that religion was an outmoded way of understanding the world, or his reduction of all natural phenomena to material forces subject to mathematical laws. For Comte had the audacity to propose that human senses, thoughts – even human society – were subject to essentially those same physical forces and mathematical laws that governed dead matter. This was hitting doxological science where it hurt. In prose conveying nothing less than jewels aquiver with rage, the *Princeton Review* fulminated upon to the release of the English translation of *The Positive Philosophy of Auguste Comte* (1855) wondering, “[w]ill M. Comte claim that it is still a matter of doubt whether men have the power of sensation, external perception, of memory, of association, of conception, of judgment?” Years later, Reverends John McClintock and James Strong took the question one step further in their *Cyclopedia of Biblical, Theological, and Ecclesiastical Literature* asking, if “nervous activity” was just a form of cold, dead, matter in motion, then “why not vital energy? and if vital energy, why not spiritual judgments and emotions?”<sup>25</sup> Indeed, they continued, why should the soul not be seen as just as meaningless as any other natural phenomenon? Seen in this light, Comte's philosophy not only stripped all meaning from science, it stripped meaning from existence.

Moreover, beyond its theologically unacceptable implications, such a belief in the material roots of the senses, the mind, and the soul foretold an epistemological tailspin that threatened the very foundations of science and, indeed, free thinking

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<sup>25</sup> “Materialism,” in *Cyclopaedia of Biblical, Theological, and Ecclesiastical Literature*, ed. John McClintock and James Strong, Vol. 5 (New York: Harper & Brothers, 1883).

Christian society. For, as McClintock and Strong put it, “if the soul is only a function of matter, then to know is one of the functions of matter. It follows that the authority of knowledge itself may be as changeable and uncertain as the changes of form, the varieties of motion, the manifold chemical combinations, of the more or less complex developments of which matter is capable.”<sup>26</sup> *The Princeton Review* echoed this sentiment and extended it. Should the absolute reliability of the senses as channels for divine reality come into doubt, then “truth is not absolute but relative – just what observed uniformities of phenomena happen to make it, to each individual, a mere dress, varying with every change of circumstance, and grade of intelligence.”<sup>27</sup> Thus lacking an absolute register for sensorial truth, each individual’s random sensory truth was as unreliable as the next person’s. And what did that make science? Nothing but superstition – *speculation*. Worse still, if such was the case, then what was the worth of the disciplined, aesthetically aware individual? *The Princeton Review* painted what was, for its readers, a worst-case scenario: the reduction of science to something like Catholicism, which was understood as synonymous with benighted superstition and autocratic rule. Should science fall into the habits of materialism, cautioned *the Review*, “[T]he hierarchy of Rome is to be supplanted by a hierarchy of atheistic speculatists [...] Pope Pius and

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<sup>26</sup> *Ibid.* This was not McClintock’s first attack against Comte. As editor of the *Methodist Quarterly Review* McClintock had in 1852 commissioned a vitriolic review of Comte’s *Cours de philosophie positiv*. Scathing though the results were, McClintock missed his mark, at least to a certain extent – Comte was pleased enough with the publicity to write McClintock an evidently ingenuous letter expressing his gratitude for the review of his book, “despite its unintentional inaccuracies, which are fortunately of a secondary character” (quoted in Harvey Wish, “George Frederick Holmes and the Genesis of American Sociology,” *The American Journal of Sociology*, 46:5, Mar. 1941, pp. 698-707, on pg. 704).

<sup>27</sup> “Compte’s Positive Philosophy,” *The Princeton Review*. 28: 1, Jan 1856, pp. 59-88, on pg. 88.

his successors are to be displaced by Pope Comte and his successors.”<sup>28</sup> For these contributors to the *Princeton Review*, science ultimately only made sense as a social activity – a deal sealed by the senses, and bespeaking of a communal bond between free thinking individuals living in the world of a creator that was just and good. Any other definition of science had little meaning as an activity that unveiled the authentic and beautiful workings of the real world.

Conservative Presbyterians theorists of science weren’t the only ones concerned about the intrusion of science into the world of sensory and religious experience. For instance, George Inness, a landscape painter and converted Swedenborgian, wrote an essay in the church’s periodical, the *New Jerusalem Messenger*, establishing “correspondences” between colors and different moral and ecclesiastical states, as he understood them through his painterly practice. Swedenborgians believed, among other things, in a doctrine of interlinked associations between the material and spiritual worlds. “Colors in the spiritual world,” explained the *Dictionary of Correspondence, Representations, and Significances*, “are manifestations of celestial light, thus of the intelligence and wisdom which is with the angels in heaven.”<sup>29</sup> But the intelligence and wisdom of the angels was not available to all, thought Inness. Establishment of color harmonies that reflected basic correspondences, he wrote, “can only be done by what artists call feeling. Science may lay down rules but they cannot be of much service in any

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<sup>28</sup> *Ibid.* on pg. 83.

<sup>29</sup> “Color,” in *The Dictionary of Correspondences, Representations, and Significances*, 4<sup>th</sup> ed. (Boston: Clapp, 1863) on pg. 69.

creative process.”<sup>30</sup> Indeed, Inness drew a connection between yellow, the color of “vulgarity” and science “which never discovers God” – regardless of how much enlightenment and wisdom one bestowed up it. As much as Presbyterians might have looked askance at systematic inquiry into the nature of the senses, they were not alone, however much the reasons differed.

Nevertheless, while many groups and individuals – Swedenborgians, Unitarians, spiritualists, and others – weighed in on the question, the Presbyterian take on connections of science, the senses, and the Almighty was among the most loudly and effectively voiced opinions in nineteenth century intellectual circles. As Bozeman puts it, doxological science was “probably the strongest tradition in science before the Civil War.”<sup>31</sup>

### Education and Disintegration

Rood was raised and educated within this conservative Presbyterian intellectual establishment. His mother was a wealthy and pious Presbyterian whose family had deep roots in the commerce and politics of New York and New Jersey.<sup>32</sup> His father

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<sup>30</sup> The entirety of Inness’s article is published in Sally M. Promey, “The Ribband of Faith: George Inness, Color Theory, and the Swedenborgian Church,” *American Art Journal*, Vol. 26, No. 1,2, 1994, pp. 44-65, on pg. 59. On Inness’s complicated and mercurial views on science in general see Rachel Ziady Delue, *George Inness and the Science of Landscape* (Chicago: University of Chicago Press, 2004).

<sup>31</sup> Bozeman, *Protestants in an Age of Science*, on pg. 166.

<sup>32</sup> Little survives in correspondence from Alida (Goveneur) (Ogden) Rood. Her father – Rood’s maternal grandfather – was Reverend Uzal Ogden, a prominent Episcopal and Presbyterian clergyman in New Jersey and himself the son of a founder of Elizabeth, New Jersey. Known for his prolific publications, “extensive library” and devoted “habits of study, observation, and reflection” Uzal earned admirers among the trustees at Princeton and Yale – though a somewhat free-thinking streak evidently earned him powerful enemies as well. In 1798 he was elected Bishop of the Diocese of New Jersey, but a body of dissenters, offended by Uzal’s “liberal views,” managed to block confirmation of the position. It isn’t clear what these “liberal views” were, though Uzal showed a noted preference for his own “extemporaneous prayers” over those sanctioned by the church, as well as a marked loquaciousness: his sermons sometimes ran close to two hours in length, and he was

was an influential Presbyterian minister, columnist, and activist for the Republican Party who took a keen and active interest in the spiritual life of his children.<sup>33</sup> Rood attended Princeton as an undergraduate, where he studied physical science with Joseph Henry and mathematics with Stephen Alexander. He continued on to postgraduate study at Yale, where he focused on microscopy and optics with Benjamin Silliman and James Dwight Dana at the newly-established Sheffield School (1847)– an institution which, along with Harvard’s Lawrence Scientific School (also 1847) was intended to enhance the presence of science at America’s leading universities. Although at least initially, Sheffield school students were segregated

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known for “multiplying divisions and subdivisions almost indefinitely.” In this sense, one might imagine that the bishop manqué could be considered as being quite liberal in dispensing his views, though the actual content of those liberal views is still unclear. In any case, as a result of the conflict, Uzal left the Episcopal Church for the Presbyterian Church, where he became friends with Alexander McWhorter, a seminal figure in nineteenth century Presbyterianism. The McWhorters and the Roods would later form a somewhat rocky friendship when the two families lived in New Haven. For various remembrances of Uzal Ogden, see “Uzal Ogden,” in William B. Sprague’s *Annals of the American Pulpit, or Commemorative Notices of Distinguished American Clergymen of Various Denominations*, Vol. IV (New York: Robert Carter & Brothers, 1859) pp 354 – 369, esp. on pg. 366 and pg. 368; on Uzal’s “liberal views,” see *The First Record Book of the Society of Colonial Dames in the State of Rhode Island and Providence Plantations* (Providence: Snow and Farnham, Printers, 1897) on pg. 161.

<sup>33</sup> Anson Rood counseled his flock that “[t]here is no depth of grief” like that felt by a parent who had failed to instill piety in their children – advice which he himself seems to have taken to heart in raising his children. He had been particularly struck by the death of his youngest son (i.e. Ogden Rood’s younger brother) Theodore, in 1847. The grief that he referred to was no doubt his own, and he seems to have determined not to commit the same mistake with his older son; his letters to Rood at Princeton consist mainly of urgent entreaties to remember God and walk in the light – as well as reminders to look after the money he sent. (See Anson Rood, “The Desolation of Families,” *New York Evangelist*, Aug 19, 1847, on pg. 130; also Ogden Rood papers, Box 1: Folder 6, MS#C0602, Princeton University Library Manuscript Division, Princeton University). As with his wife, Anson Rood’s family had deep roots in New England society, though with less to show for it financially. Anson Rood’s grandfather (i.e. Ogden Rood’s great grandfather), Deacon Azariah Rood, a recent emigrant from Scotland, participated in the battle of Bennington (actually enjoined in Walloomsac, New York) in 1777, where was promptly captured by the British, and held prisoner until 1783. After this inauspicious start, he returned to Jericho, Vermont, where he ministered and served as town selectman. His middle son, Thomas (Ogden Rood’s grandfather), moved to Connecticut, where he raised two boys, Herman and Anson, the second of whom took his education at Princeton theological seminary, and became a prominent clergyman in Philadelphia and, of course, father of Ogden Rood, color scientist. (*The History of Jericho Vermont*, ed. Chauncey H. Hayden, Luther C. Stevens, LaFayette Willbur, and Rev. S.H. Barnum (Burlington, VT: Free Press Printing Co., 1916) on pg. 190).

from Yale's main student body (earning degrees that, as historian Daniel Kevles put it, were held "in suspicion, if not disdain" by the main body of the university), Silliman and Dana were both outspoken apologists for the place of religion in modern science.<sup>34</sup> Indeed, Silliman had been recruited by Yale's president, Timothy Dwight, precisely for his combination of piety and scientific acumen, while Dana – Silliman's son in law – was both a well-respected geologist and, as his biographer Margaret Rossiter puts it, "a devout Christian who considered it the greatest work of the geologist to uncover God's plan in nature."<sup>35</sup> After two years at Sheffield with Silliman and Dana, Rood put in a year at the University of Virginia, studying analytical chemistry with William Barton Rogers and John Lawrence Smith, before returning briefly to New Haven to work as Silliman's assistant.

Rood seems, at least early in his career, to have accepted the general tenets of conservative doxological science. As a student in Germany in 1855, for instance, he wrote with great excitement to sister, proclaiming, "I have learned that organic chemistry is a pursuit for a rational man, for a philosopher, or even for a poet. [...]

One seems in this branch of science to come more closest [sic] in contact with the Maker of all things, to see him in his handiwork [sic] more face to face."<sup>36</sup> Four years later, he spoke again of the theological "poetry of science" in an address he delivered

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<sup>34</sup> Daniel Kevles, *The Physicists: the History of a Scientific Community in Modern America* (Cambridge: Harvard University Press, 2001) on pg. 9.

<sup>35</sup> On Silliman's piety see John C. Green, "Protestantism, Science, and American Enterprise," in *Benjamin Silliman and his Circle: Studies on the Influence of Benjamin Silliman on Science in America*, ed. Leonard G. Wilson (New York: Science History Publications, 1979) pp 11-28, on pp 11-12; also George Park Fischer, *Life of Benjamin Silliman, M.D., LL.D., Late Professor of Chemistry, Mineralogy, and Geology in Yale College* (New York: Charles Scribner, 1866) on pg. 44. On Dana, see Margaret Rossiter, "A Portrait of James Dwight Dana" in *Benjamin Silliman and his Circle*, pp 105-127, on pg. 125.

<sup>36</sup> Ogden Rood to Helen Rood May 1855, Box 1, Folder 9, MS#C0602, Princeton University Library Manuscript Division, Princeton University.

as a newly minted professor of chemistry at Troy University in upstate New York.<sup>37</sup>

After some preparatory remarks (including an extended review of the battle of Gravelines in 1588, in which the armada of the Catholic Spanish king, Phillip II, foundered in the English channel, thus saving Protestantism – and by extension science and reason – from an early demise), Rood treated his audience to a brief history of some of the applications of science in industry – from the effectiveness of galvanic current for etching metal, to advances in microscopy, to the use of chemistry in the manufacture of screws. But the works of humankind, as revealed through the mechanic arts, were trivial when compared to those of God. “I have shown,” announced Rood, “that a knowledge of the principles of Natural Philosophy is not only profitable but respectable; and that its possessors are taught habits of careful observation and investigation, which are useful. And now,” he continued,

it would be proper, having indicated these lesser advantages, to speak of the nobler end of such study, of its beautiful and spiritual purpose; to speak of Natural Philosophy as a revelation from ‘The great GOD, who maketh, and doeth all things well.’ But if you have not listened to his voice, speaking in His yellow sunbeams; in His banded rainbows and purple sunsets; in the violent flash of His lightening, and in the war of his tempests; or in His white crystalline snow with its blue shadows, and in his dark rivers congealed into transparent highways, solid as the rock, neither would you meditate on any crude thoughts that I might suggest.”<sup>38</sup>

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<sup>37</sup> Ogden N. Rood, “The Practical Value of Physical Science,” Address delivered July 20, 1859 (Troy, NY: William H. Young, 1859) on pg. 15.

<sup>38</sup> Rood “Practical Value,” on pg. 19.



Rood the scientist was also Rood the activist aesthete. In his address at Troy, he lauded the revelatory power of pure sunlight, and echoed the sentiments of the *Harvard Review* when he commented on the “thousands of new plants, exquisitely beautiful in form and tint” that advances in microscopy had furnished for botanists.<sup>88</sup> Indeed, in one of his first published works – an article written while he was still a student describing diffraction spectra viewed through a microscope – he spoke in similar terms of the rainbow colors that appeared when light passed through tiny apertures set on the stage of a compound microscope. Rood reported that a thin sheet of lead bearing a tiny hole with a diameter of perhaps 1/1000 to 1/10000 of an inch, for instance, will “be seen surrounded by three or four beautiful, concentric rings; the colors of the first [ring] reckoning from the centre will be yellow and faint red; the second, blue, yellow, orange, red; the third, blue, green, yellow, and the fourth, faint green and faint red.” Holes of different sizes yielded different, equally visually stunning results. A slit in “brass or tin-foil,” for instance, would give “two bands of yellow, red, blue, yellow, red, green, &c. [...] [T]he entire vision,” Rood remarked, “is exceedingly beautiful, the colors being very brilliant.”<sup>89</sup> The point, however, was not simply to delight in the beauty of the world as presented through the microscope – the point was that seeing scientifically was an

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<sup>88</sup> “On the Optical Value,” on pg. 14.

<sup>89</sup> Rood, “On a Method of Exhibiting the Phenomena of Diffraction with the Compound Microscope,” *American Journal of Science and Arts*, 15:45, May 1853, pp. 327–331, on pp 327–328. Rood also offers an interesting side note on the nature of work in even the most elite American laboratory at the time. Silliman’s facility was evidently not equipped with (or Rood had no access to) a diffraction grating – a piece of glass with finely-ruled lines, several thousand to the inch, which, if placed in the path of a beam of light, would scatter the beam into its spectral components. In order to produce a diffraction grating, Rood advised his readers that the scales of a “*Lepisma saccharina*” (a bookworm) or a “*Lycena argus*” (a small butterfly) would suffice – an interesting commentary both on the improvisation that took place in antebellum American laboratories, and on the potential for serendipitous crossovers between physics and natural science in the middle of the nineteenth century.

exercise in aesthetic discipline. “[C]areful and accurate observation is required [in scientific work];” cautioned Rood, “for while a hasty glance may suffice to inform us of certain beauties in a landscape, physical phenomena are in most cases not once to be seen, much less studied, in this style.”<sup>41</sup> Indeed, he continued, “in natural science the student is successful in direct proportion to the development of his power in discovering truth.”<sup>42</sup> To discover truth was to cultivate oneself as a conduit for scientific inquiry.

Rood particularly cast his own practice of principled looking against that of mathematical science. Throughout his career, Rood displayed an enduring dislike for numbers. As an undergraduate he voiced frustration and displeasure at numerical formalism, complaining to his sisters that algebra was an “abstruse science” (though he reckoned himself ahead of his class in it).<sup>43</sup> Decades later, as a chaired professor at Columbia, Rood persisted in maintaining a highly descriptive, experiential scientific methodology, even against the requests of his students and the tastes of his peers. Physicist Robert Millikan, one of Rood’s few graduate students throughout the color scientist’s long career, remembered that “Rood was genuinely interested in research of the *observational* sort, though he had no use for mathematical analysis and warned me against Dr. M.I. Pupin, of the mechanical and electrical engineering staff, who was trained in this and was strongly for it.”<sup>44</sup>

Indeed, Rood’s dislike of math was pronounced enough – and outré enough – that

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<sup>41</sup> Rood, “Practical Value,” on pg. 17.

<sup>42</sup> Rood, “Practical Value,” on pg. 17.

<sup>43</sup> Marg. Rood to O.Rood, 22 Oct. 1847, MS#C0602, Princeton University Library Manuscript Division, Princeton University.

<sup>44</sup> Robert Millikan, *The Autobiography of Robert Millikan* (New York: Prentice Hall, 1950) on pg. 18. Millikan ignored Rood, and pursued his own interest in mathematical physics with Pupin. He won a Nobel Prize in 1923 for his work with Harvey Fletcher on measuring the charge of a single electron.

even one of his eulogists felt compelled to note that, “[a]s a physicist, professor Rood gave but little attention to abstruse mathematical analysis.”<sup>45</sup>

The reason for his aversion to numerical formalism, Rood took pains to emphasize, was more than simple taste. Rather, for all of its vaunted logical impregnability – for all of its celestial purity – mathematics seemed to Rood to be erected on the flimsiest of foundations, bearing as it did, no link to anything more solid than human consciousness. In his address at Troy, Rood explained that “in mathematics, the source from which truths are derived is the mind itself, and its internal workings; but in physical science we contemplate the works of God, which had an independent existence, even in those early and dreary ages of our globe, when there was no animal nor vegetable life, and possibility of it was but faintly shadowed forth, in chemical and atomic life, or in the growth and decay of individual crystals.”<sup>46</sup> There could be not mathematics without a human mind to do the computations, Rood reasoned; but the same was not true of empirical science, which was based not on cerebration, but on observing that which *was and always would be* and not that which *could be or might be* depending on the mental faculties of the perceiver.

This commitment to scientific description must especially be considered in light of the fact that Rood had spent the three years prior to his engagement at Troy studying chemistry and physics in some of the leading theoretical research centers

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<sup>45</sup> W. LeConte Stevens, “Ogden Rood,” *Science*, 16: 414, Dec. 5, 1902, pp. 881-884, on pg. 882.

<sup>46</sup> Rood, “Practical Value,” on pg. 16.

in Germany.<sup>47</sup> By 1854, Rood had run the gamut of major American scientific centers (with the exception of Harvard, which was denominationally Unitarian) and decamped to Munich with the intention, as he told his sister, of studying “German, chemistry and optics.”<sup>48</sup> His first stop was the laboratory of Justus von Liebig, an aging star of continental chemistry. It was a risky move, because Liebig had recently moved his laboratory to Munich from Giessen, in part on the condition that he would no longer have to attend to students.<sup>49</sup> But Rood’s education had put him in contact with many of Liebig’s former pupils – such as John Lawrence Smith, and Rood’s close friend, Wolcott Gibbs – and, bearing their letters of introduction (as well as a helpful dose of flattery: Rood learned that Liebig preferred the honorific “Herr Baron” over “professor”) the gamble paid off.<sup>50</sup> Rood went to work in Liebig’s laboratory and was excited to discover that organic chemistry held the potential for satisfying both his career aspirations and his aesthetic appetites. “I begin to have some faint notion of organic chemist.[sic],” he wrote to his sister, “there is a great field for optical investigation among the compounds; it seems to me that a person

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<sup>47</sup> Among the most comprehensive analyses of the rise of mathematical physics in German science is Christa Jungnickel and Russell McCormmach’s *The Intellectual Mastery of Nature: Theoretical Physics from Ohm to Einstein* (Chicago: University of Chicago Press, 1986). Interestingly, the very title of the first volume of the book – “The Torch of Mathematics” – speaks to the enduring power of vision and visual metaphors in establishing claims for scientific veracity. The title is drawn from a statement by Ohm that was intended to evoke the image of light dispelling darkness – literal enlightenment through mathematical reasoning. However, as Rood attempted to point out, mathematics cannot possibly, at least in his conception, be associated with true light, since mathematics was a cerebral and therefore human-made construction, rather than a natural phenomenon. Carlo Ginzburg makes a similar point when he speaks about the “extra-sensory eye of mathematics” in his piece, co-authored with Anna Davin, entitled, “Morelli, Freud and Sherlock Holmes: Clues and Scientific Method,” *History Workshop*, No. 9, Spring, 1980, pp. 5-36; on pg. 20.

<sup>48</sup> Ogden Rood to Helen Rood, 15 Jun. 1854, Box 1: Folder 9, MS#C0602, Princeton University Library Manuscript Division, Princeton University.

<sup>49</sup> See Durand Woodman, “Centennial Celebration of the Birthday of Justus von Liebig,” *Science*, 17:441, 12 Jun. 1903, pp 952-4 on pg. 953. Reprinted also in *Pharmaceutical Review*, 21:7, July 1903, 299-301 on pg. 300.

<sup>50</sup> On Liebig’s ego, see Woodman, “Justus von Liebig” on pg. 953.

who took it up could hardly fail to make many discoveries and some important ones.”<sup>51</sup> Rood spent two years studying with Liebig, during which he made good on his ambitions to optically investigate compounds in a paper entitled “Optische Eigenschaften des fulminazsauren Ammoniaks und Kalis” (“Optical Properties of the fulminate of Ammonia and Potash”) that he published in Liebig’s prestigious *Annalen der Chemie*. Thereafter, Rood continued on to Berlin where he spent the remainder of his time in Germany studying with Heinrich Gustav Magnus and Heinrich Wilhelm Dove, both professors of physics at Berlin University. Writing to William Barton Rogers in 1858 he summed up his German experience in a sentence: “I spent three years in Europe, learning how to make oxygen from Liebig, and studying physics under Dove and Magnus.”<sup>52</sup>

Beyond making oxygen and studying physics, however, Rood’s work in Germany – particularly with Dove – was foundational to his future research in at least two respects. For one thing, in Germany Rood appears to have discovered, or at least become serious about, painting. In Munich, he reveled in the abundant (and inexpensive) art that Germany to offer. “So great! So Old! So magnificent,” he wrote to his sister, Helen, “the old forlorn looking pictures painted before art had attained respectability, the wooden statues, the old stained glass [...]”<sup>53</sup> He informed her that very old paintings could be purchased for only a bit more than the cost of dinner, and contemplated acquiring a portrait of Martin Luther by Lucas Cranach as a gift

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<sup>51</sup> Ogden Rood to Helen Rood, 17 March 1855, Box 1: Folder 9, MS#C0602, Princeton University Library Manuscript Division, Princeton University.

<sup>52</sup> Rood to Rogers, May 27, 1858, Box 3: Folder 33, MC001, William Barton Rogers Papers, Institute Archives and Special Collections, Massachusetts Institute of Technology.

<sup>53</sup> Ogden Rood to Helen Rood, 21 May, 1854, Box 1: folder 1, Rood Family Papers, MS#C0602, Princeton University Library Manuscript Division, Princeton University.

for his father (since the Presbyterian minister would've appreciated the subject). Later, in Berlin, Rood seems to have advanced his habit from connoisseurship to production, keeping a painting studio in his apartment along with a brass workshop for making scientific instruments. Berlin seems also to have been where he started thinking about the ways that painting could reveal optical phenomena. He recalled a visit with Dove to a Berlin gallery at twilight, in which the "color balance" of the paintings on the walls shifted as the light in the gallery changed.<sup>54</sup>

Also in his work with Dove, and congruent with his interest in painting, Rood seems to have become fascinated by light – not simply in questions of wavelength or optics, however, but in the ways in which human beings see. Dove was among the first generation of German theoretical physicists, and by the 1850s was one of the most productive figures in German science. Among his many studies – he published principally on meteorology, but also on electricity, acoustics, and "optical crystallography" – he was known for *Die neuere Farbenlehre* (*The New Color Science*, 1838), which was re-released "by popular demand," as Dove put it, in 1853 as *Darstellung der Farbenlehre und Optische Studien*, or *Presentation of Color Science and Optical Studies*.<sup>55</sup> The book was a late entry into the debates between supporters of Isaac Newton and those of Johann Wolfgang von Goethe over the true nature of color. At issue was the question of laboratory science versus lived experience. From his decomposition of sunlight into its apparently constituent

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<sup>54</sup> Ogden Rood, *Modern Chromatics*, on pg. 189.

<sup>55</sup> A good contemporary account of Dove's life can be found in "Heinrich Wilhelm Dove," *Proceedings of the American Academy of Arts and Sciences*, Vol. 15, May, 1879 -May, 1880, pp. 383-391. On Dove's commentary on the Goethe/Newton debates, see Dennis L. Sepper, *Goethe Contra Newton: Polemics and the Project for a New Science of Color* (Cambridge: Cambridge University Press, 1988) on pg. 4. See also Heinrich Wilhelm Dove, *Darstellung der Farbenlehre und Optische Studien* (Berlin: G.F.W. Müller, 1853) on pp. 6-9.

colors by use of a prism, Newton had surmised that the nature of color was to be found in light itself; moreover, that optical phenomena – such as color – were explicable and indeed *predictable* through mathematical analysis of Newton's experimental cases. Goethe did not disagree that the particular cases that Newton presented – for instance, passing a carefully-composed beam of sunlight through a precisely-positioned series of prisms – would yield the results he claimed. What Goethe principally disagreed with was the notion that color was, firstly, a result simply of the physical action of light rays (or, later, waves); and second that the totality of chromatic experience could be derived from a few tendentiously staged experiments. Any theory of color, Goethe argued, had to have its roots in the rich and descriptive experience of color, rather than narrowly contrived laboratory scenarios.<sup>56</sup>

Published in 1791-92, Goethe's *Beitrag zur Optik (Contributions to Optics)* was firmly rejected by the mainstream scientific community in Europe, as was its even more vehement and voluminous successor, the four-volume *zur Farbenlehre (Theory of Colors, 1810)*. In critical passages, Goethe appeared simply to misunderstand Newton's mathematical-physical explanations, while in the rest he seemed to indulge in wild polemics and romantic ramblings. By the 1830s, Goethe's color science was more or less a dead issue everywhere in Europe. Everywhere, that

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<sup>56</sup> For a close and sympathetic reading of Goethe's argument against Newton, see Sepper, *Goethe Contra Newton*. Myles W. Jackson provides a closer look at the political resonances of Goethe's color science in "A Spectrum of Belief: Goethe's 'Republic' versus Newtonian 'Despotism'" *Social Studies of Science*, 24:4, Nov. 1994, pp. 673-701. For a broader look at sensation, perception and romanticism, both German and English, see Frederick Burwick, *the Damnation of Newton: Goethe's Color Theory and Romantic Perception* (New York: Walter de Gruyter, 1986). Alan E. Shapiro gives a deep read on Newton's optical theories in "The Evolving Structure of Newton's Theory of White Light and Color," *Isis*, 71:2, Jun. 1980, pp. 211-235.

is, except in Germany, where, Dove explained, people still wanted to know “whose side are you on – Goethe’s or Newton’s?”<sup>57</sup> The best answer, Dove argued – somewhat in the face of conventional wisdom – was that neither man was completely right or wrong. Newton had his facts straight, at least as far as physics was concerned. Nevertheless, Dove proposed, Goethe had such clarity of description, such prose, such feeling – how could one resist his theories? Against this backdrop, Dove offered his own observations of psychophysical color phenomena, in particular focusing on “subjective” or individual, internal, private sensations of color. In effect, Dove had ultimately sided with Newton, but had allowed that Goethe’s general notions of experiential, scientific vision should be taken seriously by scientists at least as an addendum to practice.

One can only speculate on what, exactly, Rood thought about Dove’s defense of Goethe. On the one hand, the young man who distrusted “abstruse” mathematics and exalted in the visual poetics of science couldn’t have helped but appreciate his teacher’s spirited defense of principled observation and aesthetic experience. Goethe, of course, was no conservative Presbyterian, and indeed, outlets like the *Princeton Review* saw a pernicious theme in German romanticism – as well as Unitarianism and Transcendentalism – all of which seemed to devalue the concept of divinity by conflating God’s works, humans included, with God Himself.<sup>58</sup> But Goethe’s insistence that Newton’s mathematical optics amounted nothing more than

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<sup>57</sup> Dove, *Darstellung der Farbenlehre*, pp. 14-15.

<sup>58</sup> To put the argument another way, omni-theism was considered almost as corrosive as atheism by conservative Presbyterian theologians, because if one believes that literally everything in the world is divine – including oneself – then the concept of divinity becomes meaningless. Therefore believing that God is embodied in everyone and everything could be seen as part and parcel with believing in nothing. Romanticism was simply atheism by feast; whereas positivism was atheism by famine.



a theory – a good start, but no match for repeated and careful empirical observations – would surely have resonated with Rood. At the same time, Rood never mentions Goethe, in either published works or in correspondence – a strange oversight for one who made color his life’s work. Correspondence, of course, gets lost, or edited out of archival collections, and many of Rood’s surviving letters show signs of being redacted by scissors (though its hard to see why Rood’s heirs and editors would wish to excise his musings about Goethe). As for Rood’s published work, Goethe’s color science – whatever judicious treatment he might’ve received at Dove’s hands and those of much later apologists – was still largely considered misguided in the middle of the nineteenth century, and might have been viewed as an embarrassing citation to include in a serious scientific work on color. Indeed, in some ways, the negative reaction to Goethe’s optics among continental scientists seemed to close the door on exactly the sort of science that Rood was interested in practicing. As physicist and physiologist Herman von Helmholtz, a forceful presence in German science even early in his career, commented in 1853, Goethe’s problem was that his disposition as an artist and a poet – “some difference in organization between his mind and [those of the physicists whom he sought to convince of Newton’s error]” – precluded the sort of rigor that was necessary for modern scientific research. In essence, a finely tuned aesthetic sensibility became a moral problem, a lack of discipline – the precise opposite of the way that Rood saw it.<sup>59</sup>

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<sup>59</sup> See Herman von Helmholtz, “Goethe’s Scientific Researches,” in *Science and Culture: Popular and Philosophical Essays*, ed. David Cahan, (Chicago: University of Chicago Press, 1971), pp 1-17, on pg. 8. Also see Sepper, *Goethe contra Newton*, on pg. 5. Robert J. Richards writes that four decades after Helmholtz dismissed Goethe’s phenomenology, he reversed course, allowing that, as Richards puts it, “exercising aesthetic intuition within the realm of science [...] would not introduce anything foreign, but only aid the scientists in comprehending the fundamental structures and forces of nature.” See

What is clear, however, is that Rood returned to the United States with a subtly different outlook on the relationship of the senses to science. He still claimed to experience the touch of the Creator in the practice of science, but at the same time, God's hand was now held more closely to His vest, shrouded by electrical and chemical processes that guided the innermost lives of living things. (Indeed, one wonders at Rood's somewhat offhand mention, in his Troy address, of life only "faintly shadowed forth, in chemical and atomic life, or in the growth and decay of individual crystals." Though differing timescales of biblical and scientific creation could be easily dealt with by postulating a conversion factor between deific and sidereal days, Rood's casual remark veered dangerously close to suggesting that life was, after all, just a complicated combination of chemical products – a notion he likely picked up in Liebig's workrooms.)<sup>60</sup>

Shortly after he returned to the United States, Rood found employment as a professor of chemistry at the newly founded Troy University in upstate New York. Troy had been set up as an effort by the State of New York to produce a school for, among other things, specialized training in "Natural Philosophy and Analytical and Agricultural Chemistry" in the model of the "great German Universities" – a claim that the young scientist, fresh from working in Germany's well-administrated, state-

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Robert J. Richards, *The Romantic Conception of Life* (Chicago: University of Chicago Press, 2002) on pp 327-329.

<sup>60</sup> Rood, "Practical Value," on pg. 16. Crystals seemed to evince some of the spontaneous order that characterized living beings: they formed into distinct shapes, tended to grow then expire, and seemed to both take in and expel matter – all reliable signs of life. Of course, if life originated with the simple buildup of materials, it created the same sorts of problems as other materialist explanations of life, sensation, the mind, etc. See, for instance, Review of *Animal Chemistry* by Justus Liebig, *The North American Review*, 55: 117, Oct 1842, pp 462 -500.

of-the-art facilities, soon came to view as bitterly ironic.<sup>61</sup> When Rood arrived at Troy, the nascent university was in disarray. The star in the faculty's firmament, astronomer and mathematician John Monroe van Vleck, had fled Troy for Wesleyan University almost as soon as he had arrived, leaving an empty chair in mathematics. A second professor, a "Dr. Spencer" had quit when the trustees of the university refused to raise his salary and build a house for him. This left Marvin Vincent, a nineteen-year old philologist and theologian, as the sole professor at the university until Rood arrived. The trustees quickly appointed James Strong – McClintock's future collaborator on the *Cyclopedia* and a "back country" reverend, as Rood put it – as professor of biblical studies and *de facto* university president. In the absence of capable educators, Rood was stuck, at least initially, teaching not only chemistry, but also Greek, German, English and – perhaps worst for all concerned – mathematics. The facilities at Troy were shoddy, to say the least. Faced with "a so-called library, where four or five hundred volumes, chiefly of classical authors, were displayed on a dreary expanse of shelving; in an ill-lighted lecture-room with a few bottles of chemicals," Rood wondered whether he would be supplied with a proper laboratory, but mostly directed his energies towards securing a private bathroom for his and his wife, Mathilde's, quarters. The windows of the university leaked, and the plan for heating consisted of placing a large stove in the only room that had a chimney and heating it to the point where it would warm all of the other rooms. The food was

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<sup>61</sup> See ending note in Rood, "Practical Value," pg. 21.

bad, and Rood (perhaps) joked that he and the other professors were given rainwater to drink.<sup>62</sup>

Still, things were not all bad at Troy, and the period was one of the most productive in Rood's lifetime. Whereas at his previous assignments, Rood had peered through microscopes, spectroscopes, and prisms and published subsequent papers describing in rich detail *what* he saw, at Troy Rood began describing *how* he saw – that is, his own internalized experience of vision. As early as 1854, he had jolted with surprise when, awakening from a chloroform stupor induced in a Munich dentist's office, he saw that his "operator's" hair had turned a "bright purplish hue" – an effect that, as it wore off, Rood took to be caused by a hallucination brought on by the effects of the chloroform on the nerves of his eyes. At Troy, he undertook to induce more of these "subjective colors" in order to study, measure and describe them. He looked through plates of complementarily colored glass – one color to each eye – until his eyes grew sore, trying to identify the ways in which different combinations of "objective" colors produced "subjective" colors in his brain. He gazed into deep blue cobalt glass in order to discern what he believed to be the circulation of blood within his own retinas. He peered through perforated, rapidly rotating disks at clouds – a reliable source of soft, bright light compared with the

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<sup>62</sup> Ogden and Mathilde Rood described the poor accommodations in Troy at length and with no small measure of dark humor in several vivid letters. For the most informative of these, see Ogden Rood to Helen Rood, 7 Oct. 1858, Collection #3485, Division of Rare and Manuscript Collection, Cornell University; and Mathilde Rood to Helen Rood, ND [1858], Box 1: Folder 9, MS#C0602, Princeton University Library Manuscript Division, Princeton University. Edward Nichols quotes Marvin Vincent on Rood and Troy in short a biography of Rood published by the National Academy of Sciences; see Edward L. Nichols, "Biographical Memoir of Ogden Nicholas Rood, 1831-1902," in *National Academy of Sciences Biographical Memoirs*, Vol VI (Washington: National Academy of Sciences, 1909) pp 449-472, on pp 451-453.

warm flicker of gaslight – and watched the clouds turn strange colors as the rapid pulses of bright light passing through the patterns of holes in the disks “fatigued” his eyes. Hiking in the hills around Troy, Rood turned his head upside down and stuck it below his arm to study the effect of this strange position on his perception of the landscape, which seemed to him to appear more brightly colored from this position (a fact which was “well known” according to Rood).<sup>63</sup>

Rood was engaged in a form of science which was, to say the least, unusual among his predecessors and peers. He had conducted other studies at the same time as his proto-psychophysics – research into the shape of rifle bullets in flight (a nod to Magnus, who worked on the aerodynamics of spinning bodies<sup>64</sup>); a review article on the stauroscope (an instrument used in crystallography); a paper on the forms of electrical sparks. Psychophysics, though, was not part of the repertoire of American scientists, so Rood reached out to Henry, who among all of Rood's mentors was the most familiar with and sympathetic towards psychophysics, however rudimentary or speculative he felt it was. Henry, in return, gave Rood strong encouragement to continue. “I am pleased to learn from your note of the 16<sup>th</sup> that you are giving attention to the general subject of the spectral phenomena of the eye,” Henry began, referring to Rood’s papers on the appearance of colors generated by the spinning

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<sup>63</sup> Rood remembered his experiences with chloroform in “Observations on a Property of the Retina, first Noticed By Tate,” *American Journal of Science and Arts*, XIII, 1877, pp 158 – 159, on pg. 158; he wrote about his experiences with pieces of cobalt glass in “Additional Observations on the Circulation in the Eye,” *American Journal of Science and Arts*, XXX, 1860, p. 385, and “On a probable means of rendering visible the Circulation in the Eye,” *American Journal of Science and Arts*, XXX, 1860, p. 264; the first written announcement of what would be Rood’s many experiments with flickering disks appears in “On a New Theory of Light Proposed by J. Smith,” *American Journal of Science and Arts*, XXX, 1860, p.182; and he recorded the results of his inverted viewing in “On the Relation Between our Perception of Distance and Color,” *American Journal of Science and Arts*, XXXII, 1861, p. 184.

<sup>64</sup> See, e.g., Gustave Magnus, “Über eine abfallende Erscheinung bei rotierenden Körpern,” *Annalen der Physik*, 164:1, pp 1-29.

disk. "A good digest of what has been done in regard to these appearances is much wanted and the compilation of a brief account of all the facts belonging to this class would be an important preliminary to your own investigations." After dismissing Müller's *Physiologie des Gesichtssinns* for its lack of "positive knowledge," Henry then went on to relate his own interest in "subjective colour," stemming from "the many strange appearances which have been observed during total eclipses of the sun" – artifacts like "pink protuberances" on the surface of the sun, which Henry thought must certainly reside within the eye, if not the mind, of the observer. Henry encouraged Rood to think upon the congruencies between mechanical vibrations, electrical vibrations, and vibrations of the nerves (which were hypothesized to cause sensations), closing with, "[h]ow surprising is the co relation of different branches of science – no phenomenon stands alone and could we change the essential character of a single physical fact we would change the whole system of laws by which the universe is now governed."<sup>65</sup>

Of course, as both he and Rood were aware, the sort of psychophysical research that Henry urged Rood to perform *did* change the "essential character" of facts. Pink protuberances suddenly became artifacts of perception rather than astronomical features. Light became deceptive as well as revelatory. The yellow of His sunbeams might not be yellow as a matter of objective fact; indeed, "yellow" wasn't "yellow" anymore, but truly – in some ways, quantifiably – was only the "idea" of yellow, as Dove had put it. The entire program of doxological science was,

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<sup>65</sup> Henry to Rood, 18 Jun. 1860, Box 1, Folder: Henry, Rood Family Papers, MS#1082, Rare Books and Manuscript Library, Columbia University.

in this way of thinking, upended – not from French positivism, or American Materialism or even (really) German romanticism, but from its own aesthetic emphases turned inwards.

Rood's increased interest in psychophysics took hold in a turbulent time, both for Rood personally, for the nation politically, and for professional science socially. War had broken out in 1860 and Rood's work and those of his peers took on a distinctly martial flavor; in addition to his vision researches, for instance, Rood did work on the flight of projectiles, proving that American firearms were far more accurate and effective than their British counterparts (a lesson which so many of Rood's peers were learning, as it were, through empirical experience). As the war sucked young men from the countryside – in New York, state roughly one sixth of all able-bodied men were drafted – receipts at Troy, which had been thin at best, plummeted. Amid the banging of cannons, the school ended with a bureaucratic whimper as the New York state assembly shut down the school for failure to comply with the financial demands of its charter.<sup>66</sup> Upon hearing that her brother was out of work, Helen, writing from Germany where her husband was working in the chemistry lab of Robert Bunsen, could manage to summon up only lukewarm comfort, writing, "you will find another situation and a better one if the country is ever at rest again, but now science and art must hope for little, I suppose."<sup>67</sup>

As it turns out, both science and Rood fared better in the war years than Helen had predicted. National science gained noticeably in strength during the war

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<sup>66</sup> *Volunteer Rates in The Union Army: a History of Military Affairs in the Loyal States, 1861-65*, (Madison, WI: Federal Pub. Co., 1908) on pg. 34.

<sup>67</sup> Helen Blake to ONR, 31 Dec 1862, Collection # 3485, Division of Rare and Manuscript Collection, Cornell University.

years. True, the oldest body of professional scientists in the United States, the American Association for the Advancement of Science (AAAS) had ceased meeting for the duration of the war after its 1861 annual meeting – set to take place in Nashville, Tennessee – was canceled on account of the fighting.<sup>68</sup> But in place of the AAAS, several national bodies of science came to the fore. The National Academy of Sciences (NAS) – a body convened from among the nation’s top scientists to advise the government on “technical scientific advice in connection with the conduct of the Civil War” – developed from an informal social group of scientists like Henry, Dana and Gibbs who were committed to centralizing and strengthening American establishment science.<sup>69</sup> In contrast to the torpid AAAS, botanist John Torrey wrote Rood from an early NAS meeting, where he beheld a speaker “blazing away on gunpowder” (i.e. lecturing on it), which gave him hope that the new institution would become a significant force in advancing the cause of science and the social power of scientists.<sup>70</sup> At the same time, the Morrill Act of 1862 provided a boost to science in the form of federal funding for institutions which were, “to teach such branches of learning as are related to agriculture and the mechanic arts [...] without excluding other scientific and classical studies, and including military tactics.”<sup>71</sup> Among other schools, MIT and Cornell University used Morrill Act money to establish programs in science and technology at a time when few universities were so dedicated.

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<sup>68</sup> Kohlstedt, *The Formation of the American Scientific Community*, on pp. 226-227.

<sup>69</sup> *History of the First Half Century of the National Academy of Sciences* (Washington: National Academy of Sciences, 1913) on pg. 2.

<sup>70</sup> Torrey to Rood, 7 Jan. 1864, Box 1: Folder Torrey, Rood Family Papers, MS#1082, Rare Books and Manuscript Library, Columbia University.

<sup>71</sup> Act of July 2, 1862, ch. 130, 12 Stat. 503, 7 U.S.C. 301 et seq. (section 4).



As for Rood, the war intervened directly in his favor after Richard McCulloch, the chair of physics at Columbia College, defected to the South to take up a post as brigadier general in charge of a “military laboratory” in October of 1863 – perhaps after having served the first two years of the war as a spy for the Confederacy.<sup>72</sup> Rood lobbied vigorously for the open chair, and it seemed like the job would be his without a contest until A.P. Barnard, a prominent mathematician and astronomer, threw his hat in the ring, followed shortly by William J. Peck, an adjunct professor of mathematics at Columbia.<sup>73</sup> The three scientists and their supporters squared off. On Rood’s side were prominent members of his peer group, notably Harvard chemistry professor Wolcott Gibbs, U.S. Coastal Survey astronomer Benjamin A. Gould, and Columbia chemist Charles Joy, as well as the powerful Columbia trustee George Templeton Strong. Barnard had the backing of an older guard of scientists including Silliman, Dana, Henry, and Alexander Dallas Bache, superintendent of the Coast Survey. As his advocate, Peck principally had his own father in law, Charles Davies, a professor of mathematics at the college, but he also had the advantage of coming cheap – a plan was floated to eliminate entirely the physics chair entirely and split the science courses between Joy and Peck, so that on one day Peck would “demonstrate with the black board the physical formulae and [...] on the next day

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<sup>72</sup> See Robert A. McCaughey, *Stand, Columbia: a History of Columbia University in the City of New York* (New York: Columbia University Press, 2004) on pg.143. George Templeton Strong mentions the “military laboratory” in his diary: *Diary of George Templeton Strong*, Vol. 3, ed. Allan Nevins and Milton Halsey Thomas (New York: MacMillan, 1952) on pg. 363. Strong gives McCulloch’s rank on pg. 366.

<sup>73</sup> In a bit of unusual historical symmetry, Barnard himself had slipped across the battle lines from the South to the North. The outbreak of war found the Massachusetts-born educator teaching science and engineering in the University of Mississippi. Although a slave owner at the time, Barnard made his unionist sympathies known to friends in the north, and managed to steal into Union territory through Virginia. See A. McCaughey, *Stand, Columbia*, on pp. 149-150.

Joy should follow with the experiments.”<sup>74</sup> The suggestion of eliminating entirely the chair of physics created such a fracas among the different parties that the trustees voted to remand the question to their December meeting.

Rood narrated the fight over his nomination to his brother in law, Eli Blake, as mini civil war within American academia between science and religion. As the December meeting loomed, wrote Rood, “the Peckites and Barnardites and Roodites” geared up for a “grand battle on the ice and snow” with “those trustees representing the scientific faction” happy to have Rood as a “rallying point of some kind which will allow them to save the chair.”<sup>75</sup> Opposing Rood were “the clergy” – a group that Rood declared, in an abrupt *volte-face*, to be his “natural enemies.” A “right reverend gentleman,” he remarked, had swooped down and taken a job he had been considering at the University of Michigan before the position at Columbia became available. Now, Barnard was opposing him, and Barnard, Rood pointed out, was an Episcopal minister. Rood wasn’t sure if Davies was a man of the cloth, but “if he isn’t,” Rood thought, “he ought to be.” Once joined, the fight for the chair got personal, with Gibbs and Joy making snide comments about Barnard’s advanced age and poor hearing to the trustees, at which point, Rood thought the “gunpowder was getting too hot” and considered dropping out of the running, though Gibbs prevailed upon him to stay. Matters were coming to a head and the trustees were about to vote when, at the last minute, Rood received letters of recommendation from Dove, Magnus and Liebig: “German cannon of large caliber with which I shall fire my last

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<sup>74</sup> Rood to Eli Blake, 8 Nov 1863, Blake Family Papers, Collection # 3485, Division of Rare and Manuscript Collection, Cornell University.

<sup>75</sup> *Ibid.*

and greatest shots,” he wrote, adding “bang! bang! bang!” in what must be one of the more energetic uses of onomatopoeia in the annals of academic hiring.

In the end, Rood won the chair, while months later, Barnard was elected president of the college. But in his admittedly tongue-in-cheek analysis of his nomination battle, Rood was wrong – the fight wasn’t simply between science and religion. Indeed, one of Rood’s chief supporters among the trustees was Henry Codman Potter, the Episcopal bishop of New York, who only months before had “pronounced himself against physical science and in favor of the ‘humanities.’”<sup>76</sup> Rather, the fight over Rood’s nomination can best be seen as the final moments of a tug of war that started a decade earlier, in 1854, when Gibbs himself had been nominated to the physics chair, with the enthusiastic backing of Strong.<sup>77</sup> Two congruent problems had emerged back then: for one thing, Gibbs was a Unitarian – a liability among the Episcopal sectarians that ran Columbia. But more to the point, Gibbs had been supported with an overwhelming flow of support of letters from pious and not-so-pious scientists alike, all bearing the imprimatur of the AAAS. This had struck the college’s trustees – correctly – as a naked attempt to usurp their right to pick the school’s faculty from their immediate circles of family, friends and social peers. As such, Gibbs had been voted down, though not until the fight had been taken to the local press in an ugly scene of internecine fighting among the city’s wealthy and powerful which left many of the trustees deeply bruised (Strong, an Episcopalian like most of the trustees, had declared himself disgusted enough to

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<sup>76</sup> Strong, *Diary of George Templeton Strong*, Vol. 3, on pg. 365.

<sup>77</sup> For detailed accounts of the fracas over Gibbs’s hiring, see McCaughey, *Stand, Columbia*, on pp 121-129; also Richard Hofstadter, *Academic Freedom in the Age of the College* (New York: Columbia University Press, 1955) on pp. 269-74.

convert to Catholicism – a statement of deep distress). Rood’s nomination, then, wasn’t just a referendum on religion and politics, but rather was about the place that scientists – professionally allied to national, nondenominational bodies – should have in society.<sup>78</sup>

And what was the place that they should have? What sorts of questions would science answer? Rood’s decision to hitch his star to the wagon of skepticism has to be seen not only vis-à-vis “clergy” but also against the doxological science championed by the older guard of scientists that supported Barnard – many of whom were Rood’s own mentors. Amid the warfare of 1863, the notion that the simple evidence of the senses, lashed to a system of scientific procedure, could produce divine moral truths upon which to base a harmonious society did not hold water in the same way as it had in previous decades. Indeed, pondering the meaning of science for evaluating the truth of lived experience, Strong, a devoted Northern partisan and no enemy of science himself, grumbled sarcastically,

[A black soldier] can fight like a hero and live and die like a Christian. But look at his facial angle, sir, and the peculiarities of his skeleton, and you will at once perceive that his place is with the chimpanzee and the gorilla, not with man. Physical science is absolutely infallible, you know. No matter what the Church, or the Bible, or human instincts, or common sense may seem to say on any subject, physical science is always entitled to overrule them. It’s

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<sup>78</sup> Nondenominational in this case meant nondenominational Protestant. For more varied accounts of science and faith in the United States see David Hollinger’s *Science, Jews, and Secular Culture* (Princeton: Princeton University Press, 1996), which documents the breakdown of Protestant hegemony in American science and cultural life; and Walter Joseph Kohl’s *The Science Curriculum in the Seminary* (Saint Bonaventure, N.Y.: Saint Bonaventure’s College, 1934) which provides an interesting midcentury account of American Catholicism and institutional science.

very true that the science of 1863 has reversed or modified about 250,000 of the decisions it gave twenty years ago, but that makes no difference.<sup>79</sup>

Notice here that Strong does not say that science argues against the evidence of the senses. Indeed, he juxtaposes qualities like heroism, Christianity, instinct and common sense with observation: the things that one knows intuitively, spiritually are *not*, Strong suggests, the things that guide physical science, even if they ought to be. One of Rood's former colleagues, Charlton T. Lewis, hired as the missing mathematics professor at Troy, picked up on a similar point in an address that he delivered on the same day as Rood's 1863 inaugural lecture, in which he lamented both the inexactitude of religion and the moral chilliness of science. In their quickly changing society, did midcentury Americans need to exchange spiritual values for rational thought? Lewis wondered plaintively. "No," was the answer, because Lewis could foresee a new, morally philosophical science emerging – one with "room within for the expansion of the immortal mind, of the enthusiast's soul."<sup>80</sup> It was a science taking shape in "the History and Biography of nations and individuals, in the Annals of Crime, in the dawning truths of Physiology, and in the Records of Lunatic Asylums," and it would shape "laws as reliable as any known in the material world and far more fruitful."<sup>81</sup> Nor was this simply a fantasy of northern academics. Georgian Joseph LeConte and Virginian George Frederick Holmes both endeavored to discern laws of science that would present abolitionism as speculative idealism and preserve the social order of the South; for Holmes, his science was one which

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<sup>79</sup> Strong, *Diary of George Templeton Strong*, Vol. 3, on pg. 361.

<sup>80</sup> Charlton T. Lewis, *The Place of Mathematics in University Education*, Inaugural Address at Troy University, July 20, 1859 (Troy, NY: A.W. Scribner and Co., 1859) on pg. 8.

<sup>81</sup> Lewis, "The Place of Mathematics," on pg. 9.

attempted to “discover the true laws of social organization, with the design of thence descending to the true amelioration of the social distemper of the times.”<sup>82</sup> Laws of humankind and human behavior that were as “reliable as any known in the material world” were a sought after commodity in the midcentury United States.

### Modern Chromatics

As the chair of physics at Columbia, Rood inherited a new laboratory and a new social circle. McCulloch left behind a collection of brand new instruments before departing for Virginia – “probably the finest in the country,” Strong reckoned – and Rood quickly set to work on the new equipment.<sup>83</sup> Strong recorded with great pleasure Rood’s demonstration of the “Rumkorff” coil – a high-voltage spark generator: “the beaded streams of colored light, blue, rose-pink, and green, were most lovely – far beyond any fireworks I ever saw.” From this, Strong decided that “Rood seems a brick” (that is, a solid citizen.)<sup>84</sup> Others of Rood’s colleagues seemed to agree. Rood joined the elite Century Club – a “facility for social intercourse among gentlemen of cultivated and liberal pursuits” – where he met like-minded scientists and intellectuals like Charles Peirce, who was himself interested in color science, and indeed, literally defined color in his contributions to the *Century Dictionary* (the dictionary had no relation to the club; see chapter 4).<sup>85</sup> Along with Joy (and with

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<sup>82</sup> Holmes quoted in Harvey Wish, “George Frederick Holmes and the Genesis of American Sociology,” in *the American Journal of Sociology*, 46:5, March 1941, pp 698-707, on pg. 704; on Joseph LeConte, see Theodore Dwight Bozeman, “Joseph LeConte: Organic Science and a ‘Sociology for the South,’” *Journal of Southern History*, XXXIX, Nov. 1973, pp 565-82.

<sup>83</sup> Strong, *Diary of George Templeton Strong*, Vol. 3, on pg. 381.

<sup>84</sup> *Ibid.* on pg. 404.

<sup>85</sup> John Hamilton Gourlie, *The Origin and History of “The Century,”* (W.C. Bryant & co., printers, 1856) on pg. 5.

support of Strong) Rood was one of the few professors at Columbia to allow women to sit in on his classes – a move that earned him the reputation of a “dangerous” atheist – one of those “ ‘rationalistic professors in the chairs once occupied by the great theologians of the Church’ ” whose work was undermining the foundations of American society, as Morgan Dix, rector of Trinity Church, put it.<sup>86</sup> Rood further contributed to the breakdown of social order by taking on the cause of evolutionary theory, and was enthusiastic enough to send Darwin a sketch of a pair of ears for inclusion in *The Descent of Man* (Darwin thanked Rood through his emissary, Asa Gray, and expressed regret that the book was already in press when he had received the drawings).<sup>87</sup>

Aside from drawing ears, Rood was beginning to think seriously about painting as a means of understanding color scientifically. At a dinner party at the home of astronomer Lewis Rutherford, Rood befriended the Hudson River school painter, Frederick Edwin Church, who exhorted Rood and his wife to pay a visit to Church’s house in upstate New York – where, Church was happy to boast, he and his wife “wore old clothes” and were “not ashamed to offer our friends ham and eggs.”<sup>88</sup> Rood corresponded with Albert Bierstadt, painter of grand landscapes of the American southwest, about telegraphy and the scientific method; and with

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<sup>86</sup> Dix quoted in Rosalind Rosenberg, *Changing the Subject: How the Women of Columbia Shaped the Way we Think about Sex and Politics* (New York: Columbia University Press, 2004) on pg. 22. For general contours of “The Battle over Coeducation” at Columbia, see Rosenberg, pp 17- 47.

<sup>87</sup> Asa Gray to Rood, N.D (original note to Gray from Darwin 3 Jun. 1874), Box 1: folder 6, Rood Family Papers, MS#C0602, Princeton University Library Manuscript Division, Princeton University.

<sup>88</sup> Frederick Edwin Church to Rood, 16 May 1875, Box 1, Church Folder, Rood Family Papers, MS#1082, Rare Books and Manuscript Library, Columbia University.

Bierstadt's brother, Edward, about color photography.<sup>89</sup> As a member of the American Watercolor Society from 1867 – 1877, Rood was expected to be an active painter, and was given access to the Society's collection of works by painters (and painter-critics) such as Eugene Delacroix, John Ruskin, and Joseph Mallord William Turner, the latter of whom was central to Rood's thinking about color vision. Turner painted "nature not as it was, but as he understood it," Rood told a lecture audience at New York's National Academy of Design in 1873 – meaning that Turner understood not only the way that nature might be thought to appear *objectively*, but also conveyed the *subjective* experience of color for the viewer.<sup>90</sup>

Indeed, while through his time at Troy Rood seems to have maintained a degree of commitment to the objective truth-value of observation, by the middle of the 1860s he was fixated on the idea that his own sensual, visual appreciation of objects was not a stable property of observation but was circumstantial to the highest degree. Rood saw this interplay of objective physical stimulus and subjective sensation represented in the works of Turner, but it was by no means clear that other observers would see – or "understand" – with Turner's acuity. And yet, without some ability to communicate internal physical sensations, science could offer vastly less than even painting could for the understanding of color. As Rood put it in 1876,

The tints produced by Nature and art are so manifold, often so vague and indefinite, so affected by their environment, or by the illumination under

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<sup>89</sup> Albert Bierstadt to Rood, 22 Jun. 1885, Box 1, Bierstadt folder, Rood Family Papers, MS#1082, Rare Books and Manuscript Library, Columbia University; Edward Bierstadt to Rood, July 9, 1891, Box 2, "B" Folder, Rood Family Papers, MS#1082, Rare Books and Manuscript Library, Columbia University.

<sup>90</sup> "An Hour in Optics," *San Francisco Chronicle*, 6 Apr. 1873, on pg. 3.



which they are seen, that at first it might well appear as though nothing about them were constant; as though they had no fixed properties which could be used in reducing them to order, and in arranging in a simple but vast series the immense multitude of which they consist.<sup>91</sup>

Fortunately, Rood continued, it was possible, by means of different experimental apparatus – plates of colored glass, whirling disks of color, spectroscopes, photometers – to begin to untangle the complexities of visual experience in a scientific manner. Note here that one of the fundamental principles of the theological science with which Rood was brought up remains firmly intact: science is a practice of arranging empirical observations into general laws. Rood did not sanction *a priori* theorization. As was the case with mathematical logic, that which was purely an invention of the mind was to be held in deep suspicion. But whereas in 1846, instruments simply augmented vision – peering through a microscope simply revealed God’s wonders in ever-greater detail – by 1873, in Rood’s laboratory, instruments were essential for isolating properties of visual experience in order to subdue the observer’s otherwise untrustworthy tangle of visual sensations.

It was this focus on vision as at once embodied in a fundamentally untrustworthy observer and yet still objectively accessible that sets Rood’s work apart from other texts about color available in the 1870s. *Modern Chromatics* was not the only book on color available in the Gilded Age United States, though it was the first written by an American. Indeed, the “*Modern*” in *Modern Chromatics* was a

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<sup>91</sup> Ogden Rood, “The Constants of Color,” *Popular Science Monthly*, Oct. 1876, pp 641-648, on pg. 641.

response to British painter George Field's *Chromatics*, a text first published in 1817, which attempted to order color based on analogies to musical intervals. Although relatively unknown among chromatically-disinclined scientists of Jacksonian America, Field was widely read among painters such as Samuel F.B. Morse and Thomas Cole – who Rood would've known through the Century Club – and Field's color organization schemes were used in Marcius Willson's popular systems of object training.<sup>92</sup> Likewise, as A.H. Church pointed out some years later in his *Chemistry of Paints and Painting*, in the last decades of the nineteenth century, manuals on the chemistry of colors were abundant, and rife with unflinching and spectacular errors in the chemistry of pigment – suggestions which “may afford merriment to the chemist,” though Church found it “indeed pitiable that such teaching should be seriously offered to artists and art students.”<sup>93</sup> Perhaps the most comprehensive text on color – the English translation of which preceded Rood's book by three years – was Johann Friedrich Wilhelm von Bezold's *The Theory of Color in its Relation to Art and Art-Industry*, which treated emerging work about color physiology, but mostly stuck to Newtonian explanations of color.<sup>94</sup>

Rood was not opposed to Newton, but in his view, his predecessors had systematically failed in not properly evaluating the relationship between sensation and the physical being of the observer – not simply in laboratory science, but in the

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<sup>92</sup> On the influences of Field in American art, see P.J. Brownlee, “Color Theory and the Perception of Art,” *American Art*, 23:2, Summer 2009, pp 21-23 on pg. 21. Kohji Ogata touches on Field's influence, through object lesson teaching, in Japanese and American color education in the 1860s in “The First Color Education in Japan,” *Color Research and Application*, 11:4, Winter, 1996, pp 270-277.

<sup>93</sup> Arthur Herbert Church, *The Chemistry of Paints and Painting* (London: Seeley and Co., Ltd., 1901).

<sup>94</sup> William James, for all of his mystical leanings, seems nevertheless to have appreciated von Bezold's efforts. See William James, Review of *The Theory of Color in Its Relation to Art and Art Industry* by Wilhelm von Bezold, in *Essays, Comments and Reviews*, Cambridge: Harvard University Press, 1987, pp 331-332.

real world of lived color. On the one hand, it was important not to simply hypothesize rules of color from analogies between forms of sensory experience, as Field had done – empirical research was necessary to acquire definite facts about vision. However, in contrast to von Bezold and Church, understanding light and pigment was secondary to understanding how the functioning of the eyes, in combination with perceptual judgment, contributed to the experience of color.

Through all of the details in *Modern Chromatics* – its chapters on modes of color production, refraction, reflection, interference and wavelength – the eye is the central character. Whereas von Bezold, for instance, began his exposition of color by discussing physical theories of light, Rood opened with a scene of the “optic nerve of the living eye” subjected to electrical shocks and pressure, such that “a series of brilliant, changing, *fantastic* figures seem to pass before the experimenter.”<sup>95</sup> Rood emphasized that these figures – manifesting in brilliant shades of “bright red, green or violet and other hues” – appeared even in a darkened room, proving that “the sense of vision can be excited without the presence of light” – though since light was the stimulus most commonly provocative of color sensations, the study of light warranted close attention in Rood’s chromatics. Rood then delved into a detailed treatment of ocular physiology: the “wonderfully fine network of minute blood-vessels and nerves” within the retina, “interspersed with vast numbers of tiny atoms, which under the microscope look like little rods and cones” which, in their “mysterious manner” are “capable of being acted upon by light” and thereby send

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<sup>95</sup> Rood, *Modern Chromatics*, on pg. 9.

“nerve signals to the brain which awake in us the sensation of vision.”<sup>96</sup> Only after discussing the eyes of humans and animals, as well as the “tiny mosaics” which make up vision, did Rood come to discuss the physics of the “flood of tiny waves” propagating through an almost infinitely fine ether, which were the basis of the “undulatory theory” of light of nineteenth century physics. Whereas in his lecture at Troy Rood had insisted, in opposition to the abstractness of mathematics, that the physical world remained unchanged regardless of whether it was observed, here Rood suggested that even color – fundamental data about objects in the world – was, in fact, a property of the observer, and not of objects in the world themselves. He made the point clear again and again throughout *Modern Chromatics*. “Outside of ourselves,” Rood wrote, “there is no such thing as colour, which is a mere sensation that varies with the length of the wave producing it.”<sup>97</sup>

This did not mean, however, that “mere sensations” could not longer deliver feelings of beauty and rapture. In his chapter on the “Production of Colour by Interference and Polarization,” Rood treats his reader to an extended critique of the colors produced by light as it passes through different transparent media. “[I]n the colors of polarization we see, as it were, Nature’s mathematical laws laying aside for a moment their stiff awkwardness, and gayly [sic] manifesting themselves in play,” Rood wrote.<sup>98</sup> Different substances yielded different chromatic effects. A thin strip of selenite, for example, viewed through a polariscope or polarizing microscope, would “furnish a distinct set of tints which are peculiar in appearance, and which,

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<sup>96</sup> *Ibid.* on pg. 10.

<sup>97</sup> *Ibid.* on pg. 109.

<sup>98</sup> *Ibid.* on pg. 43.

once seen, are never forgotten; a singular tawny yellow will be noticed in combination with a bluish-grey; the yellow, which as it is, shading into an orange nearly allied to it, and this again into a brick-red [...].”<sup>99</sup> In selenite, Rood noted, there is no noticeable attempt at chromatic composition, except perhaps a little along fractured edges, where we frequently meet with pale grey or white deepening into a fox-coloured yellow, followed by a red-violet, brightening into a sea-green dashed with pure ultramarine, or changing suddenly into a full orange-yellow, after which may follow a broad field of purple. [...] The colour-combinations seldom rise into great beauty, though they often astonish and dazzle in their audacity and total disregard of all known laws of chromatic composition. The brilliancy and purity of these tints are so great, and they are laid on with such an unfaltering hand, that all these wild freaks are performed comparatively with impunity, and it is only when we proceed to make copies of these strange designs that we become fully aware of their peculiarities and, from an artistic point of view, positive defects.”<sup>100</sup>

In contrast, crystals of tartaric acid yielded “colour [...] full of gradation, touched on and retouched and wrought out with patience in delicate, complicated forms, which echo or faintly oppose the grand ruling ideas of the composition.”<sup>101</sup> Common sugar, meanwhile, produced similarly brilliant colors, though “the designs are more formal

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<sup>99</sup> *Ibid.* on pg. 45.

<sup>100</sup> *Ibid.* on pp. 45-46.

<sup>101</sup> *Ibid.* on pg. 46.

and less interesting.”<sup>102</sup> And crystals of “nitrite and potash” gave “delicately tinted threads of light [...] disposed with regularity as though it had been intended to weave them into some wonderful cashmere-like pattern, and then warp and woof had been suddenly abandoned and forgotten.”<sup>103</sup>

Nevertheless, for all of his focus on the eye, Rood was strikingly uncharitable towards his principle protagonist. Beautiful or not, color, as Rood puts it here, is a “mere sensation” – not the almost overpowering phenomenon that it had been earlier in the century. In 1852 the *Princeton Review* had sarcastically suggested that, had materialist scientists designed Creation, there would simply have been “the necessary *modicum* of light, and no more. No delicate streaks announcing His coming, no lingering beams on the purple mountains at evening; no cloud with golden fringe or bosom bathed in pearly light” – who could imagine a world like that? <sup>104</sup> Now Rood appeared to strike the pose of one of these very materialist scientists when, apparently without irony and more than three hundred pages into a book about the nature of color, he admitted, “[t]he power to perceive color is not one of the most indispensable endowments of our race; deprived of its possession, we should be able not only to exist, but even to attain a high state of intellectual and aesthetic cultivation.”<sup>105</sup> Far from being a source of moral and aesthetic uplift as well as an avenue to scientific truth, in this analysis the sensation of color is almost entirely superfluous.

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<sup>102</sup> *Ibid.*

<sup>103</sup> *Ibid.* on pg. 47.

<sup>104</sup> “Moral Aesthetics,” *Princeton Review*, on pg. 48.

<sup>105</sup> Rood, *Modern Chromatics*, on pg. 305.

Indeed, even when described in loving detail the strange colors of polarization, Rood couldn't help but temper his praise with a sharp contrast between the act of scientific observation and the exigencies of the real world. Polarized light was, Rood noted, "considered by many physicists to be extraordinarily beautiful," though he "suspected that in this case the judgment was swayed by other considerations than those of mere beauty" – polarized light was useful for investigating the structures of crystals and Rood, in effect, accused his peers of confusing utility with sensual pleasure.<sup>106</sup> And yet perhaps this was not so strange, since, as Rood mused, "[i]n ordinary life the colours of polarization are never seen; the "fairy world where they reign cannot be entered without other aid than the unassisted eye." Nevertheless, he continued,

[t]his is not a matter for regret; the purity of the hues and the audacious character of their combinations cause their gayety to appear strange and unnatural to eyes accustomed to the far more somber hues appropriate to a world in which labour and trouble are such important and ever present elements.<sup>107</sup>

Gone is the thundering omniscience of the Presbyterian God, revealing by His light the nature of the universe – in His place come tiny, slightly perverse fairies, whose play at impossible color combinations is irreconcilably separated from the drudgery of earthly perception, and irredeemably trivial for humankind's salvation.

These two convictions – laboratory science as a fairyland, and the senses as untrustworthy without the intervention of laboratory science – contributed to a

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<sup>106</sup> *Ibid.* on pg. 48.

<sup>107</sup> *Ibid.* on pg. 48.

tension running throughout *Modern Chromatics*. Because if lab science was a fairy land – if it was a “fantastic,” or “unnatural” way of looking at color – then what was the point of retreating to the laboratory to police the formerly unimpeachable credibility of the sense of vision? And if the epistemological value of vision was indeed unsalvageable, then what was the point of presenting a three-hundred page text on the psychophysics of color perception? What was Rood’s stand on the proper way to speak about – and view – color?

The answer emerges most coherently in Rood’s final chapters, which dealt with aesthetic color combinations, and combinations of color “in painting and decoration.” After a detailed treatment of how light works on the eye, how colors combine upon the retina, and how colors can be schematically arranged to bring a sense of order to the experience of ocular sensation, Rood finally confessed that science nevertheless had little to say about the production of things of beauty – it could not say how to make good art. Rood did, it’s true, attempt to provide some empirical rules of thumb. From his attempts to devise color maps, Rood could say that “colours of less than 80° or 90° apart suffer from harmful contrast, while those more distant help each other” – however, he admitted, “[i]n the case of colours that are about 80° apart, the matter remains a little doubtful.” He could also state that “[t]riads of colors that are separated by an angle of 120° are free from the defect of hurtful contrast.”<sup>108</sup> But for the production of beautiful things, ultimately, “the

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<sup>108</sup> *Ibid.* on pg. 301.



proper balance of colour is one which can not be solved exactly by any set of rules, but must be left to the feeling and judgment of the artist.”<sup>109</sup>

Nevertheless, Rood suggested, if science can't offer positive aesthetic rules, it can begin to offer explanations for why people make the aesthetic decisions that they do. With regard to color taste, Rood explained, “we are sometimes influenced by obscure and even unknown considerations. Among these may perhaps be found inherited tendencies to like or dislike certain combinations or even colours; influence of the general colour-atmosphere by which we are surrounded; training; and also a more or less delicate nervous susceptibility.”<sup>110</sup> More qualitatively, Rood noted that “the presence in a picture of a very moderate amount of a colour approaching bluish green or emerald-green excites in most persons a feeling of disgust, and causes a work otherwise good to appear cold and hard – very cold and hard.” Although most artists thought that this was because emerald green was more “intense and saturated” than other colors, Rood contended that, from a “purely optical point of view this would hardly seem to be the case.” Rather, Rood theorized, the general disgust caused by the color green was due “to the fact that green light exhausts the nervous power of the eye sooner than light of any other colour.”<sup>111</sup> Emerald green, Rood felt he could prove, is not simply “optically” more saturated – one can tell this by measuring its optical saturation through laboratory instruments. Rather its righteousness – its aesthetic viability – has to do with the relative reaction of the eye of the individual observer. This is not the absolute vision of the

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<sup>109</sup> *Ibid.* on pg. 303.

<sup>110</sup> *Ibid.* on pg. 286.

<sup>111</sup> *Ibid.* on pg. 295.

doxological scientist, or even the mathematical physicist, but rather Rood's answer to Lewis's "laws as reliable as any known in the material world and far more fruitful"<sup>112</sup> – laws centered in, but not dependent upon, the observer, that are nevertheless constitutive of moral rightness and aesthetic good.

### Conclusion

As historian of science Theodore Porter argues, the "credibility" of scientific knowledge – from mathematical proofs to experimental demonstrations – is always first and foremost a social and moral question, and Rood's psychophysics was no different.<sup>113</sup> Measuring, describing and categorizing color was, for Rood, not simply a technical feat of distilling abstract data from rich, lived experience under the aegis of a monolithic and unchanging science. Rather it was a matter of designing a science that could accommodate both the uncertainty of subjective sensation, and yet still preserve the absolute moral authority of the experience of observation. Rood's practice – in effect, the first American psychophysics – has its roots in a mélange of Presbyterian doxological science, German romanticism, and American pragmatism. It was a science that, for Rood, gained its credibility precisely because it took into account not only the ostensibly objective truth of numerical measurement, and the subjective experiences of observers, but also the moral truth-value of the previous generation's doxology.

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<sup>112</sup> Lewis, "The Place of Mathematics," on pg. 9.

<sup>113</sup> Theodore M. Porter, *Trust in Numbers: the Pursuit of Objectivity in Science and Public Life* (Princeton: Princeton University Press, 2005) on pg. 10.

By and large, Rood's reviewers praised his efforts. John Trowbridge, a physicist at Harvard, wrote that he had "never seen a scientific treatise so illuminated by what might be called the spiritual insight as this one is."<sup>114</sup> *Harper's* magazine commented that "Professor Rood's *Modern Chromatics*, has a double value, as a clear and concise presentation of the fundamental facts connected with the presentation of color, both from the scientific and from the aesthetic sides of the subject."<sup>115</sup> And Rood's friend, Peirce, writing in *the Nation*, noted that while typically "the utility and significance of visual perceptions distract attention from the more sensuous delight of color and light," Rood had managed to take into account both sides; as such Rood's was "a work so laden with untiring and skillful observation, and so clear and easy to read, that it is plainly destined to remain the classical account of the color-sense for many years to come."<sup>116</sup>

At the same time, others saw Rood's work as seriously flawed – a work, if not of nonsense, then certainly of non-science. Criticizing *Modern Chromatics* in much the same tone that Henry had used in dismissing Müller, *The American Catholic Quarterly Review* wrote that Rood's color science was overly concerned with the subjective character of color at the expense of mathematical rigor – and thus was of "slender interest and comparatively meagre (sic) utility."<sup>117</sup> Hitting somewhat closer to home, *the Nation's* editors appended to the end of Peirce's generally positive

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<sup>114</sup> John Trowbridge (possibly copied by Rood onto a piece of paper?), ND, Box 4: (no folder), Rood Family Papers, MS#1082, Rare Books and Manuscript Library, Columbia University.

<sup>115</sup> Review of O.N. Rood, *Modern Chromatics* in "Editor's Literary Record," *Harper's New Monthly Magazine*, 1879, 60:152-153, on pg. 153.

<sup>116</sup> Charles Peirce and Russell Sturgis, Review of *Modern Chromatics* by Ogden Rood, *the Nation*, 16, Oct 1879, on pg. 260.

<sup>117</sup> Review of *Modern Chromatics* by Ogden Rood, *American Catholic Quarterly Review*, IV:15, July 1879, pp. 556-557, on pg. 556.

review two paragraphs by Russell Sturgis, an art and architecture critic, who strongly disagreed with Rood's inclusion of matters of aesthetics alongside matters of science. "As to the question of whether scientific investigation is an aid to artistic production or to artistic judgment, the author seems to assume that it may be," he wrote. Nevertheless, the "more that [artists] know of these theories the less, we think, do designers respect them [...] for the qualifying terms 'good... bad... strong... excellent... weak' at once upset any claims to scientific accuracy [...]". The problem was, Sturgis wrote, that Rood proceeded from "the assumption that the scientific method can be carried beyond the discovery of fact to the laying down of positive laws for practice."<sup>118</sup> Science, for Sturgis, was necessarily a method of objective observation, not of subjective feeling.

For Rood, on the other hand, the "qualifying terms" that he used constituted the very meat of his claim to credibility. *Modern Chromatics*, and the main line of Rood's work with color, was, after all, an effort to design a science that could show people how to see *properly* – how to understand their own visual appreciation of the world both as material beings and moral observers. Vision was, for Rood, undeniably a subjective experience, embedded deep in the electrical, chemical and muscular actions of the eyes and brains of individual humans. This did not, however, imply – as the worst fears of Comte's critics might've suggested – that there was no moral anchor, no absolute experience of beauty or truth-value of observation upon which one could rely. Rather the absolute moral truth of perception was to be sought in laboratory science, practiced in everyday life, and vetted through personal

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<sup>118</sup> Peirce and Sturgis, Review of *Modern Chromatics*, on pg. 260.

experience. The observational epiphanies of doxological science were simply displaced; not erased.

Towards the end of Rood's life, the aging scientist delivered a practical example of his doctrine of vision when asked by his son to comment on impressionism – the movement in French painting whose participants had justified their practice of painting with bright splotches of color in part by referring to *Modern Chromatics*. You know that there are some painters in France, began his son, "who call themselves Impressionists; some are by a fellow called Monet, others by a fellow called Pissarro and a lot of others." Rood replied that he did. "What do you think of them?" asked his son. Replied the old man: "Awful! Awful! If that is all I have done for art, I wish I had never written that book! My son, I always knew that a painter could see anything he wanted to in nature, but I never before knew that he could see anything he chose in a book!"<sup>119</sup> At first pass, this is a deeply confusing statement – shouldn't it be the other way around? Is it not text that is deceptive, while the natural world is ingenuous? Rood's point, however, is that his scientific program was meant to restore credibility to the notion that there was, still and all, an absolute observational reality upon which one could hang one's moral and aesthetic choices. Impressionism seemed quite the opposite – a radical retreat into the eye, not an ultimately disciplined utilization of the senses. For Rood, a science of color had to offer not simply abstract sensation, but moral and physical certainty. Science wasn't simply a method of looking, but a mode of experiencing – a practice that could be carried forth with great care into modern social life as a whole.

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<sup>119</sup> Roland Rood, "Professor Rood's Theories of Color and Impressionism," *The Scrip*, 1:1, April 1906, 215, on pg. 215.

### 3

#### **Ruling out Pathology:**

#### **B. Joy Jeffries and Color Blindness in Nineteenth Century America**

##### Introduction

The chromatic world of Ogden Rood described in the preceding chapter was rich in a regular, harmonious, universally communicable experience of color. The observer's sensual knowledge of the physical world and the world itself were ultimately synchronized, harmonious; untroubled, at least with the aid of scientific apparatus and rational interpretation. True, the experience of different colors for different observers varied wildly with circumstance – and Rood (and his critics) called attention to limitations to the laboratory experience of color versus the land of “labor and toil.” But for Rood, ultimately, science was a means to normalize these varied experiences – both to provide an account of the color sensation that was commensurable across observers, and to describe *subjective* color sensations that nevertheless answered to *universals* of beauty, truth and rectitude. Regardless of different instances of perceptual variance between observers, and his own ambivalence about aspects of his program – and its applications – Rood's color

research was nevertheless geared toward affirming a longstanding confederation of vision, reason and social order.<sup>1</sup>

Color blindness sundered this association, at least as it was theorized and acted upon by nineteenth century American physiologists, ophthalmologists, and regulatory officials. Between 1870 and 1890, scholarly production of studies on color blindness in Europe and the United States increased dramatically (figure 3.1).<sup>2</sup> Beyond the realm of scientific publication, color blindness became a matter of general national attention. In the United States, it commanded the regard of

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<sup>1</sup> Among a great many texts about the entwined histories of vision, reason and order, historian Martin Jay's *Downcast Eyes: The Denigration of Vision in Twentieth-Century French Thought* (Los Angeles: University of California Press, 1993) has been particularly influential.

<sup>2</sup> Both Deane B. Judd and R. Steven Turner give helpful, if somewhat divergent, figures on color blindness literature in the nineteenth century. Judd estimates that the 1870s saw the publication of roughly two hundred texts on color blindness – a 300% increase from the 50 publications in the previous decade. In the 1880s, Judd records over 300 color-blindness-related publications, though he provides little detail on the nature of those publications. For example, it isn't clear whether Judd counts popular articles about color blindness along with scholarly articles; nor is it clear whether his figure only accounts for publications exclusively on color blindness, or includes publications that mention color blindness in conjunction with other arguments about physiological optics, and so forth. See Deane B. Judd, "Facts of Color Blindness," *Journal of the Optical Society of America*, 33:6, June, 1943, pp. 294 -307, chart on pg. 295). R. Steven Turner gives a more detailed, tabular breakdown of percentage and absolute increases in publications of different fields of vision research, including both practical and theoretical papers on color blindness. His data is drawn from a bibliography on the entire field of physiological optics compiled by Hermann von Helmholtz and Arthur König between 1885 and 1896. While Turner's statistical breakdown is, in many instances, fine-grained, he tends to lump color blindness research in with color vision research generally. Thus one discovers that articles specifically describing practical aspects of color blindness and case studies on color blindness more than doubled as a percentage of total output of articles on physiological optics between the first half of the 1870s and the second (1.6% of all publications on physiological optics between 1870 and 1874, or 9 articles; 4.6% between 1875 and 1879, or 46 articles – this during a period in which total output of all articles on physiological optics doubled); nevertheless, one also sees that "specific topics on normal and abnormal vision," "methods, apparatus, tests etc. for investigation of colour-sense," and "new literature on normal colour vision and colour blindness" made up an incredible 17.3% of all articles on physiological optics between 1875 and 1879, for a total of 174 articles. One might suppose that some percentage of this number, plus the 46 articles on dedicated color blindness, plus some portion of the previous five year's take on color blindness research would approach Judd's figure, but it is impossible to say for sure with the data breakdown that Turner presents –though it would be useful and straightforward enough to consult Koenig and Helmholtz's bibliography and compile new data thereby. (See R. Steven Turner, "Paradigms and Productivity: The Case of Physiological Optics, 1840-94," *Social Studies of Science*, 17:1, Feb 1987, pp. 35-68).

presidents and congressmen, industrialists and unions, educators and newspaper editors. Most of all, it drew the attention of the growing field of researchers of color vision, who saw in color blindness an opportunity to study sensations that – quite in opposition to Rood, Wilhelm von Bezold, and others writing popular treatises on physiological optics at the time – were difficult, if not impossible, to translate between observers. Color blindness – in its manifold varieties – was a condition that literally defied rational description, because reason implied a common descriptive constant, and the whole point of color blindness was that, simply put, the color blind didn't see what the "normal eyed" saw.

This chapter focuses on the development and proliferation of tests for color vision acuity in the United States. For Americans at the end of the nineteenth century, color blindness was a source of both wonderment and worry – wonderment over the presence of a chromatic world entirely out of the bounds of "normal" perception; worry over the mayhem such perceptual dissociation could cause in industry, society, and American culture. The dangers associated with color blindness made it an especially good topic for ophthalmologists looking to consolidate medical authority under the standard of government-backed, scientifically-informed regulation. Whereas conditions like nearsightedness represented differences in *degree* of "normal" perception, color blindness seemed to be a difference in *kind* of perception. Testing methodologies reflected the apprehension that researchers felt about the exploration of unknown sensations. Standard introspective tools – i.e. asking subjects what they were seeing – fell by the wayside, as experts felt compelled to interpret subjective responses more directly



through the physicality of the subject. Their subjects, in turn, fought back by contesting the notion that it was even possible to establish a generalized notion of color perception through abstract testing – if color perception was so literally embodied, then it mattered what the body was looking at, and under what circumstances. As such, color blindness emerged as an important test case for determining how – and even whether – color as an abstract quality, rather than a particular instantiation of everyday experience, would be treated in modern American society.

On the one hand, then, the problem of color blindness was partially academic – as historian of science R. Steven Turner notes, in Europe in particular, color blindness offered an compelling refutation of the dominant “trichromatic” theory of color vision, initially proposed by Thomas Young in 1801, then resurrected and augmented by Hermann von Helmholtz and James Clerk Maxwell in the middle of the century.<sup>3</sup> This theory was not uncontested in Europe, particularly in the 1880s, with the development of Ewald Hering’s “opponent process” theory – a theory which held that color perception resulted from receptors operating in paired, but opposing fashion (red opposing green; blue opposing yellow). Indeed, one of the attractions of opponency was that it seemed better to explain color blindness, and diagnostics based on opponent process theories of color perception – such as the familiar “Ishihara” tests with their patterns of circles and colored numbers, originally developed in Japan in the 1910s – came to dominate color blindness testing after the 1930s. Nevertheless, the main battles over opponency in color

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<sup>3</sup> R. Steven Turner, “Paradigms and Productivity: The Case of Physiological Optics,” pp. 35-68.

blindness were European in origin. While opponency was controversial in the United States, it tended to be less central to color blindness testing, and far more of an issue with questions of color and language – as will be discussed in the following chapter.

Beyond such academic conversations, however, color blindness – and its detection – also posed practical problems. In the early morning of November 14, 1875, in Lagerlunda, Sweden, two trains collided, head-on, at full speed. Nine people died; an observer at the scene wrote that the two locomotives were “raised against one another like a couple of rearing horses. The arm of one of the drivers was sticking out from the wreckage. His whole chest was ripped open, a frightening sight” (see figure 3.2).<sup>4</sup> The cause of the accident was initially thought to originate with a negligent stationmaster, but Alarik Frithihof Holmgren, a prominent Swedish physiologist, felt instead that the accident had been caused by the (now dead) engineer on one of the trains, who, Holmgren thought, had been color blind.<sup>5</sup> Holmgren agitated for – and won – the right to test the color vision of employees of the Swedish Royal railroad. His results suggested that roughly four percent of the men employed by the railroad company could not distinguish the colors used in signaling – a finding which motivated an upsurge in research on diagnosing and testing for color blindness in both Europe and America.

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<sup>4</sup> Carl Larsson, *Carl Larsson: the Autobiography of Sweden's Most Beloved Artist*, Trans. John Z. Lofgren (Iowa City, Iowa: Penfield Press, 1992) pp. 72-73.

<sup>5</sup> In addition to Larsson, for descriptions of the Lagerlunda accident see Guy Deutscher, *Through the Language Glass: Why the World Looks Different in Other Languages* (New York: Metropolitan Books, 2010) on pp. 46-48, and J.D. Mollon, “The Origins of Modern Color Science,” in *The Science of Color*, ed. Steven K. Shevell (Oxford: Elsevier, 2003) pp. 1-36, on pg. 32.

With such a compelling origin story, it is unsurprising that transportation tends to be the focus of what little historical work on color blindness exists.<sup>6</sup> By and large, historical accounts hold – in concert with period commentators – that it was the Lagerlunda crash that compelled a wave of color blindness testing across Europe and America. Optometrists Algis J. Vingrys and Barry L. Cole, for example, in “Origins of Colour Vision Standards Within the Transport Industry,” provide a fairly nuanced discussion of the history of color blindness testing as a problem (in essence) of human and machine interaction, which ultimately concludes that, much as in the nineteenth century, color blindness testing in the twenty first should be judged principally on its utility.<sup>7</sup> Among the few historians to treat the social contingencies of color blindness is Elizabeth Green-Musselman, whose paper, “Local Colour: John Dalton and the Politics of Colour Blindness,” discusses the eighteenth century association between color perception, aesthetics, and class – though, of course, the social and scientific terms of late eighteenth and late nineteenth century understandings of color blindness are very different.<sup>8</sup> This lacuna in scholarship provides an opportunity to examine nineteenth century American thinking on color perception both as a problem of immediate practical significance, as well as one with deep social and cultural resonance.

Among the more profitable ways of studying color blindness is through the work of Boston ophthalmologist Benjamin Joy Jeffries. Between 1877 and his death

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<sup>6</sup> See, e.g. Amanda French, et al, “The Evolution of Colour Vision Testing,” *Australian Orthoptic Journal*, 40:2, 2008, pp. 7- 14; and Richard Keeler, “‘Wool Over Eyes,’ Holmgren’s Skeins and Thompson’s Stick,” *British Journal of Ophthalmology*, 93:32, 2009, pg. 32.

<sup>7</sup> A.J. Vingrys and Barry L. Cole, “Origins of Colour Vision Standards within the Transport Industry,” *Ophthalmic and Physiological Optics*, 6:4, 1986, pp. 369–75.

<sup>8</sup> Elizabeth Green-Musselman, “Local Colour: John Dalton and the Politics of Colour Blindness,” *History of Science*, 38, 2000, pp. 401–24.

in 1916, Jeffries was among the leading names in American color blindness research, conducting testing programs on soldiers, sailors, rail workers, and school children. He corralled members of scientific societies into talking about color blindness; he harangued editors to run articles and opinion pieces about the importance of color blindness research; he pestered the directors of railroad and steamship companies to introduce exacting scientific tests for color blindness among their employees; and when they demurred, he hounded politicians to introduce color acuity testing standards into state and federal law. As one of Jeffries's fellow doctors gushed in the June 1894 issue of the *Railway Surgeon* magazine, "[t]o Dr. B. Joy Jeffries belongs the great credit of bringing this subject to such prominence among railway officials and to the public, and of local and general governments insisting upon the examination of the color sense wherein applicants are placed in positions important to the safety of the traveling public and to themselves."<sup>9</sup> Jeffries left little in the way of archival materials – a smattering of letters are all that appear to be publicly available, if not extant – but he and his peers published with zeal, leaving a record, if not of their unrefined fears and ambitions, then their very public wishes that color perception could serve as a foothold through which medical and scientific experts could assume a position of moral and technical leadership in modern American society.

### Science versus "The Fungus of Quackery"

As Jeffries and his peers often pointed out, color blindness wasn't a phenomenon new to the nineteenth century. As early as 1684, a Dr. Tuberville in England wrote to

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<sup>9</sup> Emmet Welsh, "Color Blindness," *The Railway Surgeon*, Vol. 1: No. 1, June 5, 1894, pp. 8-10, on pg. 8.

the British Royal Society about a case he had seen of a twenty-two year-old woman who – in addition to nightly visits by phantasmagoric bulls and bears, and an ability to read in almost complete darkness – was incapable of distinguishing shades other than grey. Jeffries thought this case too “indefinite” to properly count as a report of color blindness, and dated the first reliable case to 1777, when a Mr. Huddart wrote about a shoemaker that he had seen in Cumberland, England, who was unable to distinguish a variety of colors.<sup>10</sup> That same year, George Palmer, an English dye-maker, color theorist, mercenary soldier and all-around-fishy-character (who also went by the names Giros von Gentilly and Girod de Chantilly, evidently to avoid punishment for patent infringements) included a discussion of color blindness in his monograph, the *Theory of Colours and Vision*.<sup>11</sup> Indeed, the notion that individuals might actually possess a variable, rather than absolute – color sense seems to have made a significant enough impact in England to have caught the attention of king George III, who remarked in the 1780s to novelist Frances Burney, “there are people who have no eye for difference of colour. The Duke of Marlborough actually cannot tell scarlet from green!”<sup>12</sup>

Nevertheless, the fact that color blindness was known did not mean that it was familiar. Among the only systematic analyses of the condition until the middle

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<sup>10</sup> Benjamin Joy Jeffries, *Color Blindness: its Dangers and Detection* (Boston: Osgood and Co, 1879) on pp. 1-3.

<sup>11</sup> For a fascinating account of both the trials and tribulations of Palmer/Gentilly/Chantilly as well as those of the twentieth century researcher unfortunate enough to become fixated upon him, see Gordon L. Walls “The G. Palmer Story (or, What It’s Like, Sometimes, To Be a Scientist),” *Journal of the History of Medicine and the Allied Sciences*, XI:1, 1956, pp. 66-96.

<sup>12</sup> Quoted in Elizabeth Green Musselman, *Nervous Conditions: Science and the Body Politic in Early Industrial Britain* (New York: State University of New York Press, 2006) on pg. 58. See also Hunt, et al, “The Chemistry of John Dalton’s Color Blindness,” *Science*, 267:5200, 17 Feb. 1995, pp. 984-988, on pg. 987 n. 8.

of the nineteenth century was the respected British chemist, John Dalton's, 1798 paper describing his own color blindness. Dalton hypothesized that his condition was due to an unusual blue tint to the vitreous humor in his eyes – a guess that could only be tested to satisfaction after his death. In 1844, Dalton succumbed to a stroke, and his physician, Joseph Ransom, dutifully plucked the chemist's eyes from his head, decanting the contents of one eye into a transparent watch glass. Ransom could detect no tint, blue or otherwise. Dalton's color blindness was clearly not caused by discolored vitreous humor. The inventive Ransom then sliced the back off of Dalton's remaining eye, and, peering through it, observed that red and green objects looked much as they usually did. There seemed, therefore, to be little in the structure of Dalton's eye that would selectively filter incoming rays of light, lending credence to a remark made by Thomas Young in 1807 that "[Dalton] thinks it probable that the vitreous humor is of a deep blue tinge: but this has never been observed by anatomists, and it is much more simple to suppose the absence or paralysis of those fibers of the retina, which are calculated to perceive red."<sup>13</sup> As such, Dalton's color blindness can be seen as a key element of theorizing ostensibly normal vision<sup>14</sup> Nevertheless, as many of Dalton's biographers point out, Dalton's pioneering work in color vision is less remembered than the simple fact that the great scientist suffered a (seemingly) rare perceptual anomaly – a common enough association that "Daltonism" came to be a synonym for color blindness. Moreover,

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<sup>13</sup> Thomas Young, *Lectures on Natural Philosophy and the Mechanical Arts* (London: Printed for J. Johnson, 1807) on pg. 345.

<sup>14</sup> See David M. Hunt, Kanwaljit S. Dulai, James K. Bowmaker and John D. Mollon, "The Chemistry of John Dalton's Color Blindness," *Science*, 267: 5200, Feb. 17, 1995, pp. 984-988 on pp. 984-985. Also Charles Snyder, "The Eyes of John Dalton," *Archives of Ophthalmology*, Dec 1961, pp. 671 – 673, on pg. 673.

reviewers seldom failed to mention instances of Dalton inadvertently wearing bright clothing – for instance, the scarlet doctoral robe of Oxford – in spite of his Quaker faith, to the amusement of onlookers, if not necessarily Dalton himself.<sup>15</sup> Thus, until the advent of large-scale rail travel in the nineteenth century, color blindness seemed more an entertaining anomaly than a subject for serious science.

Railroad accidents and scientific curiosity were a *catalyst* for engaging public conversation about color blindness. However, the *motivation* to propose that hundreds of thousands – if not millions – of people be tested, or entreaties that science should assiduously begin paying attention to the scientific evaluation of color acuity, came in large part from a growing group of physicians – particularly ophthalmologists – in the United States who sought to endow their field with the professional sovereignty and social authority that would come with an alignment towards science. Jeffries was a key figure in this movement, and in color blindness he found the lever with which to hoist scientific ophthalmology – and his own practice – into the public light.

Jeffries came to ophthalmological medicine by pedigree as well as professional interest. His grandfather, John Jeffries, had been a distinguished surgeon in Boston both before and after the American Revolution; outside his medical practice, the senior Jeffries achieved a degree of celebrity when he served as Jean Pierre Blanchard's companion on the French balloonist's historic flight across

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<sup>15</sup> See, e.g. Bernard H. Becker, *Scientific London* (New York: D. Appleton and Co, 1875), pp.38-39. Also quoted in Jeffries, *Color Blindness, its Dangers and Detection*, on pg. 8.

the English Channel in 1785.<sup>16</sup> Benjamin's father – also named John Jeffries – was one of the early specialists in ophthalmology in the United States, who, along with fellow ophthalmologist, Edward Reynolds, founded the Massachusetts Charitable Eye and Ear Infirmary in 1824.<sup>17</sup> Born in 1833, Benjamin Joy Jeffries followed in his father's footsteps to Harvard, attending college then studying for three more years in the college's medical department (where his father occasionally taught), before decamping to Austria to apprentice with the notable Viennese ophthalmologist, Carl Ferdinand von Arlt.<sup>18</sup> Upon his return to Boston, Jeffries opened his own free clinic for eye and skin diseases in the city's Jamaica Plain neighborhood, and later served as ophthalmic surgeon at his father's Eye and Ear institute.

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<sup>16</sup> John Jeffries's stint as a pioneering American aviator was well timed, from a political perspective. Although he was a leading surgeon in colonial Boston, his star dimmed over the course of the colonies' conflict with England. A committed Tory, Jeffries stood as an expert witness for the defense during the trial of the Boston Massacre. When war broke out, he refused a commission as general in charge of the medical service of the Continental Army to take up a post as Surgeon-General for the British Army in North America. Shortly before the end of the war, events having gone sour for allies of the crown, he traveled to London where his wife, Sarah, and their children had relocated in order to weather the conflict. In Britain, he attempted to advance his social and political fortunes – an enterprise in which was unsuccessful, in spite of vigorous and creative lobbying, including (but not limited to) a strategic sexual liaison between Sarah and Benjamin Thompson, a celebrated and influential scientist. The Jeffries appear to have learned this trick from their acquaintances, Joshua and Elizabeth Loring, the latter of whom was very publicly the mistress of British General William Howe, to the career advantage of her husband. In the Jeffries's case, the ploy worked less well; though Mrs. Jeffries and Thompson appeared to have kept one another's company, Dr. Jeffries did not get the posts he was after; as historian J.L. Bell puts it, "Thompson rarely felt bound by unspoken agreements, or even spoken ones." While fuming over his failed attempts to play the British patronage system, Jeffries met Jean-Pierre Blanchard, who, at that point, was traveling Europe as a famous balloonist. Still in search of advancement, Jeffries suggested that Blanchard might want to take a man of science – equipped with a thermometer, barometer, and so forth – with him on his balloon flights. Blanchard agreed, though only after Jeffries bribed him. Following an initial overland foray into the atmosphere in November of 1784, the two men climbed into their balloon on January 7, 1785, and flew across the English Channel. Jeffries's attachment to this noteworthy triumph of science and technology smoothed the way for him to return to Boston, which he did in 1789. He thereafter had a stellar medical career until he died in 1819. (see: John R. Brooks, "John Jeffries: Tory Surgeon during the Flowering of Boston Medicine, 1750 to 1800," *the American Journal of Surgery*, 139:4, April 1980, pp.466 – 475; also John Jeffries, "A Tory Surgeon's Experiences June 17, 1775," *Boston Medical and Surgical Journal*, vol 92, 1875, pp.729-730; and "Sketch of the Medical Life of the Late Dr. John Jeffries," *New England Journal of Medicine and Surgery*, 1 Jan. 1820, pp.63-64).

<sup>17</sup> "Dr. John Jeffries," *Boston Medical and Surgical Journal*, 10 Aug. 1876; pp. 155-159.

<sup>18</sup> Frederick E. Cheney, "Dr. Benjamin Joy Jeffries," *Transactions of the American Ophthalmological Society Annual Meeting*, Vol. 14, 1916, pp.427-429.



Ophthalmology in America in the middle of the nineteenth century was a growth field, and the vanguard of a growing professionalization of medical specialties. As historian of medicine John Harley Warner writes, early in the century, “medical specialism had been distinctly illegitimate – a hallmark of the charlatan.”<sup>19</sup> This view changed gradually over the first half of the 1800s, as an increasing number of American medical students – over a thousand between 1810 and 1850 – returned from studying in the clinics of Paris, bringing with them an appreciation for both French medical empiricism and the French habit of classifying and studying diseases as functions of particular bodily systems.<sup>20</sup> Specialism brought with it advantages, including its suggestion of desirable expertise and experience that doctors could use to distinguish themselves in the competitive medical markets of antebellum America.<sup>21</sup>

Ophthalmology – along with otology and dermatology – were particularly acceptable forms of specialism early in the century. As historian P.J. Brownlee writes, starting in the 1820s a tide of concern over the taxing nature of a burgeoning print media upon the country’s fragile optical globes swept through American society.<sup>22</sup> To meet this need, specialized clinics on the Parisian model sprung up in

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<sup>19</sup> John Harley Warner, *Against the Spirit of the System: the French Impulse in Nineteenth-Century American Medicine* (Princeton: Princeton University Press, 1998) on pg. 292.

<sup>20</sup> Much has been written about the Parisian – and later, German – influence on western medicine. For an excellent sustained treatment, see, e.g. Warner, *Against the Spirit of the System*, 1998; for a more brief – but no less enlightening – gloss, see Roy Porter, *The Greatest Benefit to Mankind: A Medical History of Humanity* (New York: W.W. Norton, 1997) on pp. 306-347.

<sup>21</sup> Paul Starr, *The Social Transformation of American Medicine* (New York: Basic Books, 1982) on pp.76-77.

<sup>22</sup> Peter John Brownlee, “Ophthalmology, Popular Physiology, and the Market Revolution in Vision, 1800–1850,” *Journal of the Early Republic*, 28:4, Winter 2008, pp. 597-626. It should be noted that it’s not entirely clear whether Brownlee is suggesting that nineteenth century Americans *thought* their eyes were in danger, or whether print media actually introduced a less contextual sort of danger to

major urban centers. The 1824 Massachusetts Charitable Eye and Ear Infirmary was just one among many institutions opened in mid-nineteenth century America that specialized in eye care. The first, physician Elisha North's New London Eye Infirmary, operated from 1819 to 1829. The New York Eye and Ear Infirmary opened its doors shortly after New London's, in 1820. In Baltimore, George Frick founded a dispensary for eye care in 1823. Boston's followed in 1824, and Philadelphia's Wills Eye Hospital opened in 1834.<sup>23</sup> These institutions – typically philanthropic rather than proprietary – served simultaneously as sources of care for patients who couldn't afford treatment otherwise, as workrooms where specialists could practice their field, and as sites for the production of scientific and clinical knowledge about treatment of eye diseases. Dr. George McClellan of the Wills Hospital, for example, urged the physicians of Philadelphia to send their non-paying patients with eye diseases to his care, because to do so would “confer a favor on the managers [of the hospital] and will forward the interests of science.”<sup>24</sup>

“Science,” however, did not necessarily imply a commitment to what would be recognizable in the twenty first century as sound biomedical practice. Antebellum medical reforms based on European models emphasized attention to empirical medicine over “theoretical” or “rationalistic” medicine, but, as Warner notes, “neither principle nor theory necessarily bore much relation to actual

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American vision which thereby necessitated a special focus on eyes. A minor quibble, perhaps, but one with resonance for theorizing the conjoined histories of medicine and perception.

<sup>23</sup> On the development of American eye clinics in the early nineteenth century, see Alvin Allace Hubbell, *The Development of Ophthalmology in America, 1800 to 1870* (Chicago: W.T. Keener and Co., 1908) on pp.16-38.

<sup>24</sup> Hubbell, *The Development of Ophthalmology in America*, on pg. 24.

therapeutic practice.”<sup>25</sup> While particular medical theories varied widely from physician to physician, in general, for treatments to be considered effective – and, therefore, for a doctor to remain in business – both physicians and their patients had to agree on what was proper and expected from a particular therapy. At least for practitioners of orthodox medicine, this meant an allegiance first of all to highly visible therapeutic practices – as opposed to programs of research which might be less visible to patients – and, more theoretically, to some variation on the traditional physiological theories of humoral medicine, according to which an individual’s health was governed by balance among four fluids, or humors. When the humors were in balance, the patient reported good health; when they were out of balance, the patient felt sick. It was the physician’s job to balance the body’s humors, typically through bloodletting or purgatives on the one hand, or the use of strategic irritation of the skin (e.g. through caustic chemical agents, or heat) to draw the humors into alignment.<sup>26</sup> These therapies worked because, on the one hand, both physicians and their patients understood the humoral system; and on the other, humoral therapies appeared to *do something*, indicating their – and the physician’s – efficacy.

Thus one finds in the *American Journal of the Medical Sciences* detailed accounts of cutting-edge humoral ophthalmology in Philadelphia in the mid nineteenth century. In a case study written by ophthalmologist George Fox, for instance, Susan Smith, a twenty-three year old seamstress, visited Wills in 1839

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<sup>25</sup> John Harley Warner, *The Therapeutic Perspective: Medical Practice, Knowledge, and Identity in America, 1820 – 1885* (Princeton: Princeton University Press, 1997:1986), on pg. 5.

<sup>26</sup> See, e.g. William G. Rothstein, *American Physicians in the 19<sup>th</sup> Century: from Sects to Science* (Baltimore: Johns Hopkins University Press, 1985) pp. 41-54.

having lost sight in both of her eyes. The cause of her blindness, Fox explained, was an “asthenic condition [i.e. weakness] of the retina, with some local congestion,” for which Fox prescribed a course of purgative “senna” tea and “moxas” to the temples.<sup>27</sup> The purgative tea was of general assistance in relieving the fluid imbalance implied by the congestion, while moxas – a technique borrowed from Japanese therapeutics in which burning herbs were used to gently warm the skin – represented a state of the art treatment for restoring humoral balance in cases of sensory and nervous disorders.<sup>28</sup> Likewise, when Mary Bishop, young “seegar” maker, reported to Wills Hospital with a rare case of color blindness, she was treated with a course of bloodletting, mustard compresses to her inner thighs and breasts, blistering of her lower back, a vegetable diet, and the fortnightly application of fifty to sixty leeches on her temples.<sup>29</sup> As with the seamstress, Bishop’s physician, Isaac Hays, traced her color blindness to a humoral imbalance in her body – in this case, her failure to menstruate for several months. In both cases, the doctors reported, treatments were a success and patients regained their full range of sight. Though their treatments seem outrageous from the perspective of twenty-first

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<sup>27</sup> George Fox, “Report of Cases of Diseases of the Eye treated in the Wills Hospital during the months of April, May and June, 1839,” *American Journal of the Medical Sciences*, Nov. 1838, pp. 13-23, on pp. 13-14.

<sup>28</sup> In a fascinating article, Anú King Dudley describes the history of moxa as a humoral therapeutic between approximately 1820 and 1840. Called to the attention of European physicians through the observations of Dutch missionaries in Japan, moxa gained strong adherents among leading physicians in France, England and the United States. While Japanese moxa tended to consist of fine herbs ignited very quickly directly on the skin, physicians in the United States and Europe preferred cigar-like contraptions (or, in one instance, a dried sunflower stalk stuffed with herbs) to create heat without burning the patient. On the use of moxa both in general and in curing blindness see Anú King Dudley, “Moxa in Nineteenth-century Medical Practice,” *the Journal of the History of Medicine and Allied Sciences*, 65:2, 2010, pp. 187-206.

<sup>29</sup> Isaac Hays, “Report of Cases treated in the Wills Hospital for the Blind and Lame during the months of October, November and December, 1839, with Observations,” *American Journal of the Medical Sciences*, Aug. 1840, on pg. 280.

centry biomedicine, Fox and Hays were not quacks, nor were they medical reactionaries. Rather, both practiced good, clinical, *empirical* medicine, as they and many of their peers understood it.<sup>30</sup> They kept meticulous logs of their patients' past histories; noted the causes of their patients' diseases and their prescriptions for remediation; detailed the courses of day-to-day treatments; and – importantly – published their results in a leading medical journal so that their work would contribute to a growing body of knowledge about disease and treatment.

Though by no means a homogenous, rapid, or uncomplicated process, by the end of the Civil War, medical practices based on therapeutic action and humoral theories gave way to medicine based on specific diagnoses and laboratory experimentation.<sup>31</sup> Earlier in the century, New England, with its tradition of therapeutic moderation, provided a fertile ground for European medical practices which emphasized systematic study and classification of the particulars of disease

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<sup>30</sup> Warner, *Therapeutic Perspective*, 28.

<sup>31</sup> Scholarship on changes in American medicine between the nineteenth and the twentieth centuries is extensive and diverse, but tends to focus on two mutually-reinforcing shifts, viz. movements towards professionalization, and changes in clinical practice. The education and competency of individual doctors varied wildly over the course of the nineteenth century, as did medical authority and the social status of physicians. Faced with increasing public mistrust, and competition from alternatives to orthodox medicine such as homeopathy and Thompsonian medicine, in the late nineteenth century orthodox physicians (and, later, some “unorthodox” doctors as well) banded together to pressure state legislatures to enact strict licensing laws that dictated the amount and type of education necessary for an individual to practice medicine. At the same time, although an emphasis on “science” tended to mark much discourse on good medical practice throughout the 1800s, the exact meaning of “science” and “scientific” medicine varied widely; as greater and greater numbers of American physicians received their training in European clinics, medical practice in America increasingly came to be focused on experimental medicine and diagnostics as well as therapeutics. In practice, professionalization and the rise of experimental medicine were entwined in complicated ways, and the best scholarship tends to integrate these two threads in nuanced ways while preserving a focus on either professionalization or clinical practice. On professionalization, see, e.g. Paul Starr, *The Social Transformation of American Medicine*, (New York: Basic Books, 1982) on pp.76-77; and Joseph F. Kett, *The Formation of the American Medical Profession: the Role of Institutions, 1780 – 1860* (New Haven: Yale University Press, 1968); on clinical practice, see Rothstein, *American Physicians in the 19<sup>th</sup> Century*; Warner, *The Therapeutic Perspective*.

over (or, anyway, alongside) heroic action like bloodletting and blistering.<sup>32</sup> This model proved increasingly effective as a means of evading the ostensible rigidity of traditional medicine and reducing infighting among orthodox physicians. At the same time, beginning in the 1850s, Paris faced increasing competition as a center of medical education from Teutonic cities such as Berlin and Vienna. While seldom uniform in their appreciation, understanding or application of new scientific medical practices, students – such as Jeffries – returned from their studies in Austria and Germany versed in the beneficial aspects of “specialism, diagnostic instruments, and reliance on the experimental laboratory” which they passed along to their peers and implemented in practice.<sup>33</sup>

As a young doctor, Jeffries was on the forefront of pushing a Viennese model of medical science in ophthalmology, convinced that it would yield both better results for patients and – as importantly – confer greater respect and professional autonomy on ophthalmologists. In June of 1865 Jeffries delivered a key address at the second annual meeting of the American Ophthalmological society. His lecture – delivered to a group of twenty attendees who gathered at the New York Eye and Ear infirmary – was a call for members to “to learn, appreciate, and adopt all advances in ophthalmological science as well as in ophthalmological medicine and surgery.”<sup>34</sup> American ophthalmology, he noted, had made appreciable inroads as a sovereign medical discipline in the past several decades. Nevertheless, Jeffries quoted one

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<sup>32</sup> On New England’s traditional restraint when it came to heroic treatments – especially as contrasted with the gusto shown by Philadelphia doctors – see Warner, *Therapeutic Perspective*, 22-31.

<sup>33</sup> Warner, *Against the Spirit of the Times*, on pg. 313-314.

<sup>34</sup> B. Joy Jeffries, “Report on the Progress of Ophthalmology During the Past Year,” *Transactions of the American Ophthalmological Society Annual Meeting*, 1:2, 1865; pp. 2-12, on pg. 4.

“non-medical” writer who complained, “In the ordinary diseases to which the eye [...] is subject, we may safely confide in the skill of the experienced physician; but in the diseases to which it is liable as an optical instrument, where optical science can alone direct us, we regret that professional assistance is difficult to be found.”<sup>35</sup> A skilled doctor might competently perform eye surgery or “craft an artificial pupil,” remarked Jeffries, but to truly care for a patient’s sight, one had to understand the science of vision – particularly physiological optics of the sort practiced by German physicist and physiologist Herman von Helmholtz and his followers.

As specific examples of the sorts of knowledge called for by newly “*scientific ophthalmologists*,”<sup>36</sup> Jeffries called his audience’s attention to research in Britain on the optics of the “accommodation and refraction of the eye;” on advances in knowledge of the physiology of the retina; and – the most “attractive field for physiological and psychological study” – research into “the means by which [...] retinal impression becomes visual perception,” or, “theory of vision.”<sup>37</sup> Absent, in Jeffries index of appropriate courses of study for ophthalmology, were heroic therapies based on the appearance of action. Instead, Jeffries emphasized that practices – such as autophthamscopy, which allowed one to view one’s own retina through a specially devised instrument – “sprung from philosophic ophthalmologists applying the laws of optics to physiology. It was not stumbled on, but wrought out by patient investigation and experiment.”<sup>38</sup> Nevertheless, Jeffries conceded, many of his peers might ask, “how has all of this laborious

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<sup>35</sup> *Ibid.*

<sup>36</sup> *Ibid.*

<sup>37</sup> *Ibid.* on pp.8-9.

<sup>38</sup> *Ibid.*

experimentation helped us?”<sup>39</sup> Jeffries’s answer was that it was only through this sort of experimentation – theoretical work in laboratories as well as clinical work – that he and his fellow ophthalmologists could “retain the position which our medical brethren are according us, and which is the surest means of shaking off from our specialty the fungus of quackery springing up from the soil of ignorance.”<sup>40</sup>

It is not clear precisely when Jeffries first settled on color blindness as his tool for uprooting the fungus of quackery. Certainly, the range of his research in the late nineteenth century was broad enough to support his eventual specialization. As early as 1868, Jeffries was interested in questions of physiological optics such as the persistence of vision and stereoscopy.<sup>41</sup> Reporting on the accomplishments of ophthalmology at an 1871 meeting of the American Ophthalmological society Jeffries noted “extremely interesting” work in color perception by M. Woinow and would have been familiar with a talk – presented at the same meeting – by physician Henry Noyes on “An Apparatus For Testing the Perception of Color” (in this case, simply a disk that could be rotated to reveal different colors to the examinee; figure 2.3).<sup>42</sup> Nevertheless, in describing his own work, Jeffries focused on the enucleation of an “intra-ocular tumor” and some studies he had done on “visual acuteness;” moreover, in *the Eye in Health and Disease*, a treatise he published the same year,

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<sup>39</sup> *Ibid.* on pg. 7.

<sup>40</sup> *Ibid.* on pp. 8-9.

<sup>41</sup> “American Ophthalmological Society,” in *The Medical Record*, 3, 1868, on pg. 273-274.

<sup>42</sup> B. Joy Jeffries, “Report on the Progress of Ophthalmology,” *Transactions of the American Ophthalmological Society Annual Meeting*, 1:8, 1871, pp.13 – 59, on pg. 22; Henry N. Noyes, “An Apparatus for Testing the Perception of Color,” *Transactions of the American Ophthalmological Society Annual Meeting*, 1:8, 1871, pp. 118-119.



Jeffries mentions color blindness only once, in passing.<sup>43</sup> Yet by the time of an 1873 meeting of the Boston Society of Medical Sciences, Jeffries was well-versed and intensely interested in the physiology of color vision, particularly noting the work of German physiologist Max Schutze's work on so-called "cone" cells in primate retinas which were theorized to be the receptors in the retina responsible for color vision.<sup>44</sup> In 1874 he was appointed to an Examining Board for examining candidates for the state's militia – a job that may have involved testing the visual sense of new recruits.<sup>45</sup> (Late in the Civil War, the Union Army instituted color vision tests for its soldiers, and it's possible that the Massachusetts militia pondered adopting similar procedures – though, in the case of the Union Army the tests were part of a program to collect "anthropological" statistics rather than determining fitness for duty, and, as a measure of their relative importance the vision component of the schedule of data were added late and largely as an afterthought.<sup>46</sup> It is thus difficult to say with certainty whether Jeffries considered examining recruits for color blindness in his role as a military surgeon).

What is clear is that by early 1877, perhaps as a result of the Lagerlunda crash, Jeffries was preoccupied with color vision in general, and color blindness in particular. In February he wrote to the Massachusetts Board of Railroad Commissioners asking about the state's color acuity standards for railroad men and

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<sup>43</sup> See Jeffries, "Intra-Ocular Tumor. White Fusiformed Cell Sarcoma. Enucleation" (pp. 26-27) and "Visual Acuteness" *Transactions of the American Ophthalmological Society Annual Meeting*, 1:8, 1871, pp. 158 – 160. See also Jeffries, *the Eye in Health and Disease* (Boston: Alexander Moore, 1871) on pg. 44.

<sup>44</sup> "Reports of Medical Societies," *Boston Medical and Surgical Journal*, 89:17, 23 Oct. 1873, pp 406-408, esp. pg. 407.

<sup>45</sup> "Editorial," *Boston Medical and Surgical Journal*, 3 Dec. 1874, on pg. 549-550.

<sup>46</sup> Benjamin Apthorp Gould, *Investigations in the Military and Anthropological Statistics of American Soldiers* (New York: Hurd and Houghton, 1869), on pg. 548.

sailors (there were none).<sup>47</sup> He checked Chevrue's *des Couleurs* and George Wilson's *Color Blindness* out of the Boston Public Library and found them worthy of notice.<sup>48</sup> He solicited a copy of Wilhelm von Bezold's *Theory of Color* from its translator, Sylvester Rosa Koehler – the Louis Prang Lithography Company's technical director, who was soon to be named editor of the *American Art Review* and the first curator of prints at the Boston Museum of Fine Arts.<sup>49</sup> The two men hit it off, and that February, in frequent correspondence with Koehler, Jeffries set about recreating some of von Bezold's experiments on subjective color vision using the ubiquitous spinning disks of psychophysical investigation. For several months, Koehler and Jeffries traded tips, test results, and research materials.<sup>50</sup> In March, Jeffries began a series of color sensitivity diagnostics using a set of disks that Koehler had produced for him; Jeffries thanked him, writing, "I mean [to] work up my color tests by the disks you made for me and will report any results I get."<sup>51</sup>

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<sup>47</sup> Jeffries, *Color Blindness*, on pg. 138.

<sup>48</sup> Benjamin Joy Jeffries to Sylvester Rosa Koehler, 11 Mar. 1877, in "Benjamin Joy Jeffries, Correspondence, 1877-1891," Crerar Ms 202, Special Collections Research Center, University of Chicago.

<sup>49</sup> Jeffries to Koehler, Date Unclear, Feb 19? 1877, in "Benjamin Joy Jeffries, Correspondence, 1877-1891," Crerar Ms 202, Special Collections Research Center, University of Chicago.

<sup>50</sup> Jeffries's wife was apparently an active participant in his research. She was responsible for making some of the disks, and evidently participated as a test subject in his color experiments; it seems that Jeffries and Koehler were trying particularly to recreate some of von Bezold's experiments in subjective color mixing: see Benjamin Joy Jeffries to Sylvester Rosa Koehler, 20 18 Feb77; and Jeffries to Koehler, 21 18 Feb77, both in "Benjamin Joy Jeffries, Correspondence, 1877-1891," Crerar Ms 202, Special Collections Research Center, University of Chicago.

<sup>51</sup> Benjamin Joy Jeffries to Sylvester Rosa Koehler, 11 Mar. 1877, in "Benjamin Joy Jeffries, Correspondence, 1877-1891," Crerar Ms 202, Special Collections Research Center, University of Chicago.

### Communities of Color and the Culture of Science

That very month, Jeffries delivered his first two public lectures on color blindness – one to the “Thursday Club,” a gathering of upper-class professionals interested in contemporary science, and the other to the Boston Society of Natural History.<sup>52</sup> The topic of both talks was “color blindness in relation to locomotive engineers and [boat] pilots.”<sup>53</sup> In a talk enlivened with “diagrams and experiments” (as the minutes of the Boston Society’s meeting relate), Jeffries “gave an account of the theory of color blindness, and the practical relations of the subject.”<sup>54</sup> In these talks, Jeffries attempted to strike a popularizing chord. The day before his lecture at the Thursday Club, Jeffries made the somewhat curious gesture of apologizing in advance to Massachusetts Institute of Technology founder William Barton Rogers for the “almost infantile” presentation of his topic. While his treatment of the material might seem “very elementary,” Jeffries explained that it was imperative that he didn’t confuse audience members. He suggested that rather than judging his talk on

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<sup>52</sup> Clubs such as the Thursday club, the Wednesday Evening Club and the Saturday Literary Club were a fixture of elite intellectual life in late nineteenth century Boston. Boston’s leading men (and only men) met in the parlors of their peers for drinks, discussion and typically a short essay or two, often by an expert in their field, on the topic of a current artistic, scientific, or social issue of the day. While George Ellis, in his entry in the *Dictionary of Boston*, suggests that by 1886 the intellectual rigor of club life was fading – “the deaths of Hawthorne, Agassiz, Peirce and Longfellow” having “somewhat dimmed its intellectual brilliancy,” Louis Menand traces the birth of American pragmatism to debates that took place among the young William James, Chauncey Wright, Charles Peirce and Oliver Wendell Holmes during the 1880s at meetings of their “Metaphysical Club” (see especially, Louis Menand, *The Metaphysical Club* (New York : Farrar, Straus, and Giroux, 2001). For the quote describing the “Thursday club” see entry for “Club Life in Boston” in George Ellis, *Bacon’s Dictionary of Boston*, (Boston: Houghton Mifflin, 1886) on pg. 108. A brief synopsis of active Boston clubs can be found in Moses King, *King’s Handbook of Boston* (Moses King: Cambridge, MA, 1878) on pg. 236.).

<sup>53</sup> B. Joy Jeffries to William Barton Rogers, 28 Feb. 1877, Box 5: Folder 74, Institute Archives and Special Collections, Massachusetts Institute of Technology.

<sup>54</sup> “General Meeting. March 7, 1877,” *Proceedings of the Boston Society of Natural History*, Vol. XIX, (Boston: Printed for the Society, 1878), on pg. 80.

its content, Rogers might better ask attendees, “did you understand the doctor?” as a measure of his success.<sup>55</sup>

Jeffries’s caution in presenting his work on color blindness is suggestive of just how strange color blindness seemed to nineteenth century Americans – even those interested in science, as was the case with the audience at the Thursday Club. Other outlets could be less subtle: “Peculiar Freaks of Color Blindness,” cried the headline of an otherwise bland article on color blindness testing in the *New York Sun* (reprinted in the *Los Angeles Times*).<sup>56</sup> The language of freakishness was hard to evade, even for those who wished to present an even-handed view of color blindness; physician W.B. Harlow described his own inability to distinguish between certain hues in *Science* in 1888 as “due to a freak of nature.”<sup>57</sup>

In some ways, though, the language of strangeness was an improvement over the sheer skepticism that had surrounded color blindness earlier in the nineteenth century. For instance, the editors of *the Monthly Stethoscope*, a southern medical journal, were blunt in their 1856 dismissal of a report by the British ophthalmologist, George Wilson, in which Wilson claimed that no fewer than one in eighteen people likely experienced some sort of color blindness. “[I]nstead of this being the case,” the editors wrote, “we have never known but one case of color-blindness; we are therefore skeptical of the correctness of Dr. Wilson’s experiments.”<sup>58</sup> In a more measured review of the color blindness research of

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<sup>55</sup> B. Joy Jeffries to William Barton Rogers, 28 Feb. 1877, Box 5: Folder 74, Institute Archives and Special Collections, Massachusetts Institute of Technology.

<sup>56</sup> “Peculiar Freaks of Color Blindness,” *Los Angeles Times*, 1 Jun. 1902, pg. 15.

<sup>57</sup> W.B. Harlow, “Color Blindness,” *Science*, XI: 261, 3 Feb. 1888, pp. 57-58, on pg. 58.

<sup>58</sup> “Color Blindness,” *the Monthly Stethoscope and Medical Reporter*, 1:9, Sept 1856, pg. 609.

Scottish physicist David Brewster and Swiss physiologist Elie Wartmann in 1845, American scientist Joseph Henry remarked that, with one or two exceptions, “[o]bservations on this peculiarity of vision have as yet been confined, so far as we know, to Europe.”<sup>59</sup> As late as 1877, the Massachusetts Board of Railroad Commissioners wrote to Jeffries that “‘the subject of color-blindness is one which has never come to the attention of the board;’ and they ‘have not known of the subject being investigated in this country.’”<sup>60</sup> Indeed, even when faced with evidence of the condition among their own employees, people were often incredulous: “In the Directors’ room of a railroad corporation,” Jeffries recalled,

I had shown the officials the practical results of defective color sense by instances from among their employés. They could not and would not understand or admit it. One otherwise pleasant old gentleman sank back in his arm chair, and with almost a snarl of doubt and derision exclaimed, ‘Why Dr. Jeffries I have been railroading more than forty years; now if such a thing as color blindness existed, I must know all about it.’<sup>61</sup>

Jeffries argued for the importance of widespread color acuity testing – if not the ordinariness of variable color perception – by appealing to notions of community, as in his 1878 report to the State Board of Health in Massachusetts. “It is quite commonly known,” began Jeffries, “that there are certain people in the community who cannot distinguish ripe cherries or strawberries from leaves except by their form. It seems to be about equally well recognized that this is only a sort of

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<sup>59</sup> Joseph Henry, “On Color Blindness” *Princeton Review*, July 1845, Vol XVII, pp. 483-489, on pg. 487.

<sup>60</sup> Jeffries, *Color Blindness*, on pg. 183.

<sup>61</sup> Benjamin Joy Jeffries, “Re-Establishment of the Medical Profession, part 1,” *Boston Medical and Surgical Journal*, Vol. 118, 21 Jun. 1888, pp. 613-618, on pg. 614.

curiosity of no special importance to the community at large.”<sup>62</sup> The situation was different, however, if the individual was not picking strawberries, but running a train or steamship – a situation in which “passengers’ lives, not to speak of their property, are dependent upon [...] his instantaneously distinguishing between a red and green light.” In these instances, Jeffries noted, “the mere curiosity part of color-blindness sinks into insignificance in comparison with the danger arising from it. The community then awakens to a sense of the importance of asserting its rights.” This was not a theoretical danger, Jeffries made clear. He treated the Board of Health to a rich recitation of rail and steamship accidents cause by color blindness – Lagerlunda included – which, he noted, had prompted many European governments to adopt vision tests among rail men and sailors. Moreover, “the magnitude of the danger,” Jeffries noted, “depends on the magnitude of the defect,” and these European programs of color blindness testing had indicated that up to five percent of the male population had some form of anomalous color perception. Was the case any different in the United States? No, said Jeffries. Rather the apparent infrequency of color blindness could be explained by methods of diagnosis: “[v]ariable statistics are given by different observers, depending largely upon the methods of testing for color-blindness; the more thorough and scientific these latter are, the greater being the number of color-blind individuals found.” Least effective was the method favored by American transportation companies of simply letting cases reveal themselves. Given “the prevalence of color blindness, the value of scientific investigation in detecting it, [and] its danger for the community,” Jeffries concluded,

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<sup>62</sup> Benjamin Joy Jeffries, “Dangers Arising from Color-Blindness,” in *Ninth Annual Report of the State Board of Health of Massachusetts* (Boston: Band, Abernethy and Co, 1878) pp. 99–129, on pg. 99

it was vital that the government implement a comprehensive program of color blindness testing – run by experts and predicated on science.<sup>63</sup>

Jeffries's emphasis on rail disasters had a great deal of resonance in America in the 1870s. As historian Barbara Welke writes, in the decades following the Civil War, rail accidents changed the ways that individuals thought about bodily injury, personal liberty, and corporate responsibility. "The daily human toll of accidents," writes Welke, "punctuated at ever more regular intervals by horrific disasters claiming the lives of hundreds in a single accident, generated a tide of anger at corporations that seemed increasingly distant even as they penetrated the landscape more thoroughly."<sup>64</sup> In antebellum America, accidents had been seen as a part of life; individuals were generally responsible for their own safety. In contrast, the scope and frequency of railroad accidents during the Gilded Age seemed to demand government intervention to hold corporations liable if they neglected to insure the mental and physical health of their patrons. Failing to screen employees for color blindness was one example of this new sort of corporate liability. Following a talk by Jeffries before the Railroad Committee of the Massachusetts State Legislature in 1879, an editorial in the *New York Times* demanded a "mandatory statute" that would insure that "railroad and steam-boat companies [would] be compelled to exclude from their service employes [sic] in whom this, or any other, defect of vision exists."<sup>65</sup> Echoing this sentiment, Kansas physician John Fee wrote, "[the fact] that color-blindness is the source of accidents and calamities on railroads,

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<sup>63</sup> Jeffries, "Dangers Arising from Color-Blindness," on pg. 112.

<sup>64</sup> Barbara Welke, *Recasting American Liberty: Gender, Race, Law and the Railroad Revolution, 1865-1920* (Cambridge: Cambridge University Press, 2001) on pg. 3.

<sup>65</sup> No Title ("Editorial"), *New York Times*, 23 July 1879, pg. 4.

in which property and life are sacrificed, is as apparent as any fact in pure mathematics." He urged the Kansas state legislature to consider whether "some protective legislation can be secured against railroad collisions, so as to render transit on railways less perilous to life."<sup>66</sup> Likewise, the *Detroit Lancet*, a medical journal, wrote that "the public should be so educated as to demand this protection. [...] Such color vision, we hold, these companies are now bound to guarantee as one of the means for safe conveyance."<sup>67</sup>

It should be said that, in spite of the assertions by Jeffries and other editorialists that color blindness "explain[ed] many hitherto inexplicable railroad and vessel accidents," the facts were not so clear-cut.<sup>68</sup> Perhaps unsurprisingly, those with an interest in avoiding the time and costs that would be incurred by mass color blindness testing did not feel that variations in subjective perception were an issue. A survey of railroad superintendents by *Railroad Age* magazine found that none of the thirty two respondents were aware of any accidents caused by color blindness, and only six thought that testing of any sort was a good idea.<sup>69</sup> On the other hand, in an 1889 article praising Jeffries for his accomplishments, the Massachusetts Medical Society nevertheless felt the need to hedge, writing, "though [color blindness], until lately but little known, *may not be proven* as a common cause of the fearful accidents by land and by sea, with which our papers daily teem, its

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<sup>66</sup> John Fee, "Color Blindness and Railway Accidents," *Transactions of the Kansas Academy of Science*, Vol 7, 1879-1880, pp. 29-37.

<sup>67</sup> Leartus Connor, "Dangers from Color Blindness," *The Detroit Lancet*, 1:8, August, 1878, pp. 632-633, on pg. 633.

<sup>68</sup> *Ibid.*

<sup>69</sup> Marshall Monroe Kirkman, *Railway and Train Station Service: Describing the Organization and Manner of Operating Trains and the Duties of Train and Station Officials*, (Chicago: C.N.Trivess, 1885) on pg. 89.



*probability* as a misleading agent cannot be too strongly maintained.”<sup>70</sup> Indeed, more common than accidents related to color blindness were simple mechanical failures in the signals themselves. Traditionally, for instance, white was the rail signal for “go” while red was the signal for “stop” – those two colors being commonly accepted as the most visible at a distance. On daylight signs, this [protocol] worked reasonably well; at night, however, it was not uncommon for the red glass on the “stop” lantern to crack or fall off entirely, revealing the unfiltered white light source and reversing the meaning of the signal. Similarly, as gas and electrical lighting grew more common in buildings and along streets, the sudden abundance of bright, white lights along rail lines generated confusing signals for engineers. As a result, green gradually replaced white as the signal to proceed – since green was seen as the chromatic opposite of red – but signaling standards were slow to be uniformly enforced.<sup>71</sup> As for the Lagerlunda accident – the germinal event of color blindness testing – a 1975 article by F.G. Frey convincingly argues, based on detailed court

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<sup>70</sup> George Townsend, “The Position of the Massachusetts Medical Society,” in *Medical Communications of the Massachusetts Medical Society*, Vol XIV., Boston: David Clapp & Son, 1889, pp. 9- 39, on pp. 20-21. Italics added.

<sup>71</sup> There is an interesting body of historical and anthropological work on the social meaning of traffic signals. In his 1970 book, *Claude Levi Strauss*, anthropologist Edmund Leach proposed that traffic signals were an excellent example of the ways in which human cultures are structured upon their phenomenal sense of natural reality. Red, for Leach, is the color of danger – and therefore a signal to stop – because of its deep associations with blood. Green, as the chromatic opposite of red, makes for a natural signal to proceed. It is therefore only natural that yellow – which Leach describes as midway between green and red in the spectrum, would be used as a signal to proceed, albeit with caution. Leach’s interpretation was subject to criticism on historical grounds – for instance, by Frederick C. Gamst – who pointed out that, historically, white and red had been the original duo of signal lights, and that even after white was seen as a non-viable color for night signaling, much debate ensued over which colors to use. Indeed, he points out that “red” is not the ultimate danger signal on railroads – a blue light on a train means that it is not to be moved under any circumstance, for instance, because people are working under it. Ultimately, Gamst sees the colors used in traffic signals as products of a scientifically-motivated debate rather than a structural tie between nature and culture. See Edmund W. Leach, *Claude Levi-Strauss* (New York, Viking, 1970) pp. 24-28; and Frederick C. Gamst, “Rethinking Leach’s Structural Analysis of Color and Instructional Categories in Traffic Control Signals,” *American Ethnologist*, 2:2, May, 1975, pp. 271-296.

testimony of the accident, that the crash was not, in fact, caused by color blindness as Holmgren had supposed, but by a failure on the part of both the engineer and the stationmaster to act within regulations.<sup>72</sup> In this sense, the rush to color blindness testing was predicated on a falsehood.

In some ways, though, the specific truths of the accidents described by Jeffries and his peers were beside the point. The “community” that Jeffries envisioned wasn’t just one free of transportation accidents. Rather, it was a community guided by the beacon of science instead of commerce – and it was one in which expert scientists (and medical doctors) had greater sway over public policy than railroad directors. “Nothing but the ignorance or stupidity of railroad and vessel managers stands in the way of accomplishing [widespread colorblindness testing],” fumed *the Detroit Lancet*.<sup>73</sup> In less temperate moments, Jeffries was inclined to go further, describing his work to rid the rails of color blindness as “a fight between one man against sixty million people.”<sup>74</sup> At other times, Jeffries was more reflective, remarking that, “[o]ur profession cannot contend with what is called business in the accumulation of wealth.”<sup>75</sup> Nevertheless, “[w]ealth is a mighty power, but it falls palsied before knowledge.” Since the end of the Civil War, Jeffries continued, old social hierarchies had been broken down, in the face of what he called “culture” – that is, a commonly shared sense of knowledge, refinement, aesthetic taste. “I think I see the signs of culture becoming a social force,” he wrote.

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<sup>72</sup> F.G. Frey, “Ein Eisenbahnglück vor 100 Jahren als Anlass für systematische Untersuchungen des Farbensehens,” *Klinische Monatsblätter für Augenheilkunde*, vol 167, 1975, pp. 125-127.

<sup>73</sup> Leartus Connor, “Dangers from Color Blindness,” on pg. 632.

<sup>74</sup> That is, Jeffries saw color blindness testing as himself versus the entire population of the United States in 1883, plus about eight million people. It’s not clear from whence the additional reinforcements came. “Testing of Color Blindness,” *New York Times*, 25 Oct. 1883, on pg. 4

<sup>75</sup> Jeffries, “Re-establishment,” on pg. 200.

“In such a society our profession [i.e. physicians] should be, and duly recognized there.”<sup>76</sup> This was the meaning of the “guarantee” of color vision – it was a guarantee of membership in a community – a society – in which scientific “culture” held sway over wealth; it was a guarantee of rational order in the face of seeming chaos; a guarantee of expert knowledge over corporate greed.

### The Best of the Worsteds

In recommending a course for color blindness testing, Jeffries leaned heavily on the work of A.F. Holmgren. He had been corresponding with the Swedish physiologist since mid 1877, when he began canvassing the ophthalmologists of Europe for their opinions on color blindness testing. Jeffries had hoped to be the first to translate Holmgren's *Om Färgblindheten: i dess förhållande till jernvägstrafiken och sjöväsendet* (*Color Blindness in its Relation to Accidents by Rail and Sea*) into English, but was scooped by M.L. Duncan at the Smithsonian Institution.<sup>77</sup> Nevertheless, his exchange of letters with the Swedish physiologist gave Jeffries an abiding respect for Holmgren's scientific acumen as well as his practical usefulness; in addition to acting as Holmgren's translator for outlets such as the *Boston Medical and Surgical Journal*, Jeffries copied large chunks of Duncan's English translation of *Om Färgblindheten's* into *Color Blindness: its Dangers and Detection*, and he dutifully dedicated the book to the Swedish scientist. Holmgren's chief concern was devising

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<sup>76</sup> Jeffries, “Re-establishment,” on pg. 199.

<sup>77</sup> See M.L. Duncan, trans, *Annual Report of the Board of Regents of the Smithsonian Institution*, Washington: G.P.O., 1877, pp. 131 – 195. On Jeffries' wish to translate Holmgren (presumably from German, in which he was more fluent than Swedish) see “Color Blindness,” *the Nation*, Vol 39: 734, 24 July 1879, on pg. 62.

color testing standards for rail employees; in so doing, however, he necessarily formulated a relationship between sensation, knowledge, and physicality that formed the backbone of his testing regimen.

The most basic means of testing an individual's color perception was simply to present him or her with a variety of colored objects, and compare the test-taker's description of the objects' colors with the test giver's. In the case of Mary Bishop, the color blind "seegar" maker at Wills hospital, for instance, Hays simply pointed to objects of different colors and asked Bishop what she saw. "With the exception of yellow and blue," reported Hayes, "all the other colours were named with much hesitation, and some only after our insisting on her doing so, and she then manifestly named them by guess."<sup>78</sup> Later that month, Alexander Dallas Bache, a prominent Philadelphia scientist and correspondent of Dalton's, stopped by the hospital with some colored cloth squares that Dalton had sent to him, labeled with the chemist's idiosyncratic descriptions of their hues. Bache presented the swatches to Bishop in an effort to compare her eyesight with Dalton's – an interesting experiment, but one in which, as Hays drily noted, "[n]othing new or worth recording was elicited."<sup>79</sup> In any case, as Bishop got better, she was able to tell the difference between the color of the flowers and leaves on a rose bush, and could identify the colors of different roses brought before her. Towards the end of her treatment, her color perception had seemingly returned completely, with the

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<sup>78</sup> Isaac Hays, "Report of Cases treated in the Wills Hospital for the Blind and Lamé during the months of October, November and December, 1839, with Observations," *American Journal of the Medical Sciences*, August 1840, pp. 277- 285, on pg. 278.

<sup>79</sup> *Ibid.*

exception of the color violet, which she consistently misnamed – a fact that Hays implied might simply be related to her “moderate intelligence.”<sup>80</sup>

The paddle proposed thirty years later by Henry Noyes for testing color acuity (figure 3.3) was only moderately more sophisticated. Instead of colored objects, Noyes recommended pasting “slips of colored paper [...] as numerous as is thought needful” onto the central body of the paddle, which could then be rotated to reveal a single color in the window of the overlying black envelope.<sup>81</sup> The test was designed so that only one color would be visible at a time. Test takers were to sit in front of a blackboard and to “fix one eye upon a distinct mark near its centre.”<sup>82</sup> The examiner would then hold the paddle up to the board at different points around the fixed mark, thereby introducing a succession of colors into the visual field of the examinee. As the examiner moved the paddle and shifted the colors, the examinee was to name the color that he or she saw; the examiner would then place a mark in the appropriate color on the black board. In this way, it was possible to secure a record of the color sensitivity of an examinee’s entire visual field – though Noyes’s method was hardly systematic, nor especially well suited to determining particular types of color blindness.

For Holmgren, however, tests that simply required aspirants to name colors – especially asking rail workers to name the colors or meanings of signal flags and lanterns – had marked disadvantages. For one thing, in the case of rail workers, a color blind employee might simply make a correct identification based on a

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<sup>80</sup> *Ibid.* on pg. 280.

<sup>81</sup> Henry N. Noyes, “An Apparatus for Testing the Perception of Color,” *Transactions of the American Ophthalmological Society Annual Meeting*, 1:8, 1871, pp. 118-119; on pg. 118.

<sup>82</sup> *Ibid.*

combination of random guesswork and subtle nuances in the position and type of signal. Naturally, Holmgren admitted, over a long run of tests, a truly color blind person would make revealing mistakes, thus exposing his condition. But how many test runs were enough to correctly ascertain an examinee's perceptual acuity? One? Ten? One hundred? Purely on the basis of time and efficiency, color-naming tests had to be considered impractical. For another thing, wrote Holmgren, tests requiring their subjects to name colors might also snag "normal-eyed" employees who, through "carelessness, inattention, or even from *lapsus linguae* [i.e. through a slip of the tongue]" failed to correctly identify the colors of test lanterns and flags.<sup>83</sup> One might wonder which scenario really posed more harm to the public good: a color blind railroad employee who could distinguish signals correctly, or a "normal-eyed" railroad employee who was too careless to pay attention to them. Nevertheless, the point of testing was to root out color blindness, not incompetence, and thus tests based on an individual's ability to *name* colors were viewed – by Jeffries and Holmgren – as largely ineffective.

It was important not to underestimate the caginess of the color blind, and Holmgren pulled no punches in describing the process of color blindness testing an essentially an adversarial clash between "examiner and examined" – one in which, if proper care was not taken, "the latter may readily often win, and where the former bears all the loss if the examined afterwards fails once."<sup>84</sup> "The color blind," wrote Holmgren, "acquire from practice a peculiar capacity for distinguishing colored

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<sup>83</sup> Quoted in Jeffries, *Color Blindness*, on pg. 185.

<sup>84</sup> *Ibid.* on pg. 184.

signals.”<sup>85</sup> It was precisely this “peculiar capacity” that had to be overcome in order for a test to be deemed successful. Color blindness testing was, in essence, a matter of wrenching the truth of sensation from an uncooperative subject, and a successfully-formulated test therefore had to alienate color from any cues that might allow potentially color blind test takers to rationalize their way to a correct – if dishonest – description of the nature of the physical stimulus being presented to them.

The way to do this, Holmgren and Jeffries believed, was to devise a test that would short-circuit an individual’s ability to apply reason and language to their appreciation of color sensations. “The object of the test is to ascertain a subjective sensation from an objective expression,” wrote Holmgren. “Now, man has but one means of expressing his subjective sensation to another; namely, by muscular action.”<sup>86</sup> The particular muscular actions that Holmgren had in mind, he clarified, were those of the tongue and the hands – that is, speech on the one hand, and picking, sorting and handling on the other. “It is scarcely necessary to indicate,” he continued, “that, as a rule, it is [the hands] which we rightly have greater confidence in than the spoken word.”<sup>87</sup> Speech was untrustworthy. Actions spoke louder than words. “We must [...] remember,” cautioned Holmgren, “that the names [that the color blind] give colors are often exactly adapted to conceal their defect. If it is in his [i.e. a color blind test subject’s] interest [...] not to expose his defective perception, but rather to conceal it, he certainly can do this better by speech than by the hands

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<sup>85</sup> *Ibid.*

<sup>86</sup> *Ibid.* on pg. 207.

<sup>87</sup> *Ibid.*

[...] this is why we maintain the principle that it is necessary to leave to the activity of the hands the task of revealing the nature of the sensations and to have recourse to the tongue only for verification when there is need of more information.”<sup>88</sup>

In order to comply with his own theoretical demands for a color testing regimen, Holmgren devised a test based on strands of “Berlin worsted” – a type of yarn that was cheap, readily available, and came in a wide variety of bright, consistent colors. The procedure behind the test was simple. As Holmgren described it:

The Berlin worsteds are placed in a pile on a large plane surface, and in broad daylight; a skein of the test-color is taken from the pile, and laid aside far enough from the others not to be confounded with them during the trial; and the person examined requested to select the other skeins most resembling this in color, and place them by the side of the sample.<sup>89</sup>

It was not necessary for participants to match test colors exactly; rather the point of the test was for the person being examined to select the skeins of yarn that best matched the shade of the test-color, while eschewing those skeins that would not match for “normal” color perception.

To assist examiners in selecting their colors and judging the results, Holmgren supplied (and Jeffries reprinted) a plate showing sample “test-colors” and sample “confusion colors” – i.e. the control colors, and the colors that a color blind person would erroneously match to the control, respectively (figure 3.4). In the figure, the horizontal bars labeled by Roman numerals represent the test-colors;

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<sup>88</sup> *Ibid.*

<sup>89</sup> *Ibid.* on pg. 210



vertical bars labeled with Arabic numbers represent the confusion colors.

Holmgren's procedure is meant to progress sequentially from steps I through III, and the plate indicates the different diagnoses signified by the [examinee's] choice of colors – “normal” vision, on the one hand, or “red-blindness,” “green-blindness,” or “violet-blindness” on the other. Holmgren cautioned, however, that the plate was only to be used as a guide, and neither as a definitive standard for the colors of the wools, nor as a color blindness test in itself. In the first place, the printing technologies available for replicating Holmgren's plate could not possibly match the variety, intensity, and consistency of the hues in which Berlin worsteds could be purchased (which, after all, was what made them ideal materials for testing color blindness in the first place). For another thing, the printed chart presented colors already set out in a prescribed order – a fact which negated the very muscular activity of picking and sorting which was so essential in forcing the color blind to reveal themselves.

Holmgren and Jeffries insisted that it was important that an expert “surgeon” (as railroad doctors were called) administer the test. For one thing, even if the tests were relatively uniform, the people taking the tests could vary a great deal in terms of class, intelligence, education and cooperativeness, and it took experience to avoid mischaracterizing mistakes or subterfuge as greater or lesser indicators of color acuity. “The examination is most difficult,” noted Holmgren, “with people of small intelligence, or of feeble and uncultivated color perception.” The same was true of those who knew they were colorblind but wished to hide it, and – less frequently – the normal-eyed who wished to feign color blindness. In some instances people

simply appeared not to understand the test – Holmgren reported cases where participants simply plucked the test skeins willy-nilly from the pile and placed them next to the control skein. It was in these moments when the skill of the administering ophthalmologist was crucial for determining whether participants were really color blind or just overly enthusiastic. Indeed, Holmgren claimed, relying on body language alone, a truly expert test administrator could “detect color-blindness by the first gesture of the examined.”<sup>90</sup> Jeffries, meanwhile, suggested on more than one occasion that he could diagnose color blindness simply by observing the visage of a potential test taker, remarking “I have now and then made my diagnosis correctly, from a peculiar, dazed, half-anxious expression of the face and eyes of a looker-on awaiting his turn.”<sup>91</sup> In this instance, it should be pointed out, it was neither the muscles of the tongue nor of the hands that told the truth, but rather those of the (no-doubt anxious) face – which, Jeffries mused, when “called into play from mental impressions through the eyes,” might very well give “the colour-blind eye its own peculiar facial expression.”<sup>92</sup>

Holmgren’s test was immensely popular in the United States, where Jeffries publicized it relentlessly, but it wasn’t the only method of testing color blindness in the late 1800s. In 1880, for instance, the massive Pennsylvania Railroad commissioned William Thompson, a Philadelphia ophthalmologist, to screen the ocular health of its 40,000 employees, including testing for color blindness.

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<sup>90</sup> *Ibid.* on pg. 208

<sup>91</sup> See Jeffries, *Color Blindness*, on pg. 67.

<sup>92</sup> Benjamin Joy Jeffries, “Observations on a Peculiar Expression of the Eyes of the Colour-Blind,” in *Transactions of the International Medical Congress, Seventh Session* (William MacCormac ed, London: J.W. Kolckmann, 1881) pp. 121-122, on pg. 122.

Realizing that it would be impossible for him personally to conduct Holmgren's test on thousands of men scattered across twenty states, Thomson endeavored to "render [the Holmgren test] more simple," such that a "non-professional person [...] could conduct the testing, record it properly, and transmit it to an expert capable of deciding upon the written results."<sup>93</sup> In practice, that is, no expert medical oversight would be required – any literate railroad employee on the scene could handle the administration of the test.

The method Thomson chose – decided on through "theory based on scientific knowledge" – was to hang the most common confusion colors on a thin board, interspersed with skeins of the control colors. Each color skein on the "stick," as the board was called, was assigned a number, one through 40. The control colors all received even numbers; the confusion colors, odd numbers. To obscure the numbers from test takers, the stick was fitted with a hinged cover that slid over the numbered tags, while letting the yarn hang free (figure 3.5). As with the Holmgren test, the examinee would be shown the control skeins – green, rose and a bright red color – and asked to select similarly colored skeins from those hanging on the stick. The examiner would record the numbers of the skeins that the test taker picked, and the numbers would reveal – to the expert who ultimately viewed the record – whether the test taker was color blind or fit to work. The record of a "normal-eyed" examinee, for instance, would show only even numbers. Red blind examinees would show odd numbers corresponding to the rose and blue colors numbered 21, 23, 25,

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<sup>93</sup> Edward Nettleship and William Thompson, *Diseases of the Eye* (Philadelphia: Lea Brothers & Co., 1890) on pg. 464.

27 and 29, while green-blind examinees added odd numbered skeins colored with off shades of green and with gray.<sup>94</sup>

As a cheap and efficient alternative to the Holmgren test, “Thompson’s stick,” as it was known, was quite popular. It suffered, however, from at least two key defects. As Charles Oliver, a Philadelphia ophthalmologist, noted, Thompson’s was first of all a “fixed test” – one which relied upon a constant and “discoverable” plan, and thus violated Holmgren’s “fundamental principle” that the candidate be simply given a “mass of color matches from which to take his choice.”<sup>95</sup> Secondly, and more practically, in addition to the unchanging layout of the skeins, Oliver pointed out that Thomson relied on a “fixed method of nomenclature,” which, if it became known – which was not unlikely, given that it was to be administered by the test-takers’ peers – would be “rendered practically worthless.”<sup>96</sup> Another railroad surgeon, John Ellis Jennings, affirming Oliver’s opinions, similarly complained that, on the one hand, “[a]s the worsted is attached to a stick, any choice to be made by the person examined is greatly curtailed;” while on the other, since “the skeins are arranged in regular order, alternating match and confusion skeins, this [system...] is liable to become known and the test thus rendered worthless.”<sup>97</sup>

Answers to the difficulties of Thompson’s and Holmgren’s test abounded.

Oliver, for instance, proposed his own wool test, based on similar hues to those of Thompson and Holmgren, but with the addition of blue and yellow – colors which he

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<sup>94</sup> For a comprehensive look at the functioning of the “stick” test, see Nettleship and Thompson, *Diseases of the Eye*, on pg. 461-473.

<sup>95</sup> Charles Oliver, “A Series of Wools for the Ready Detection of ‘Color Blindness,’” *Transactions of the American Ophthalmological Society*, Vol. 6, 1893, pp. 538-541, on pg. 539.

<sup>96</sup> *Ibid.* on pg. 538.

<sup>97</sup> Jennings, *Color Vision and Color Blindness: a Practical Manual for Railroad Surgeons* (Philadelphia: F.A. Davis Company, 1868) on pg. 68.

thought essential to the proper diagnosis of color blindness. Furthermore, although like Thompson, Oliver labeled his skeins for easy record keeping, his wools were tagged with a symbolic nomenclature that would be “incomprehensible to all but the scientifically initiated” thus limiting the risk of the test’s secret falling into the wrong hands. As of the mid 1890s, Oliver claimed to Jennings that his system was “in use on some of the largest railway systems [in the United States]” though it is difficult to say with precision which ones he referred to.<sup>98</sup> At the same time, William Dennett – a New York ophthalmologist (and friend of Ogden Rood’s) proposed that subjects be given a set of one hundred and forty seven wool balls colored in control and confusion colors and told to throw them into one of three green, rose, or red trays. The balls would be akin to Holmgren’s wools in variety of colors, and would fulfill the requirement that examinees be physically engaged in the task of distinguishing colors, but – like Thompson’s test – each ball would be tagged with numbers because, as Dennett sagely noted, “numbers are occasionally convenient in making records.”<sup>99</sup> Meanwhile, Emmett Welsh, railroad surgeon for the Grand Rapids and Indiana Railroad Company, confronted potential employees with a smorgasbord of nineteenth century color perception tests. First, he tested potential hires with the Holmgren test. Then he tested them with the Thompson test. If the

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<sup>98</sup> Oliver, “A Series of Wools for the Ready Detection of ‘Color Blindness,’” *Transactions of the American Ophthalmological Society*, Vol. 6, 1893, pp. 538-541, on pg. 539; Around 1894, Thompson modified his test to include yellow and blue as well – possibly a response to Oliver, as well as to Hering’s theories of color perception, as promoted by Christine Ladd-Franklin, as described in chapter 3 (see Jennings, *Color Vision and Color Blindness*, on pg. 68). For Jennings’s correspondence with Oliver, see Jennings, *Color Vision and Color Blindness*, on pg. 70.

<sup>99</sup> William S. Dennett, “Holmgren’s and Thomson’s Worsteds in a New Form,” *Transactions of the American Ophthalmological Society*, Vol. 4, 1886, on pg. 261; On Dennett’s interest in testing see, e.g. Colman W. Cutler, “William S. Dennett,” *Transactions of the American Ophthalmological Society*, 23 1925, pp. 13-15.

employee failed either or both, Welsh then took them to a life-sized replica of the back of a caboose that he'd had constructed, complete with red, green and white lanterns powered by electric bulbs (figure 3.6). At a distance of forty feet, the applicant would be quizzed on the colors of the lanterns as they flashed on and off. Welsh conducted this last phase of testing less as a safeguard against wrongly indicting a potential hire and more as a proof of the other two tests. That is, Welsh thought it likely that anyone who failed the Holmgren or Thompson test was color blind, but felt he needed the faux-caboose to "prov[e] conclusively to the managers and the most skeptical observer the correctness and importance of the observation."<sup>100</sup> The fake caboose was necessary not to diagnose but to dramatize color blindness.

Railroad workers were not the only group that Jeffries tested, though they were the ones he recommended legislating most avidly. In 1879, he took Holmgren's wools into Boston's grammar schools, high schools, and a number of technical schools to test the students for color blindness – a "long-continued labo[r][...] in the cause of science," through which Jeffries hoped to convince educators that diagnosing color blindness was necessary to shaping the development of America's youth.<sup>101</sup> Preemptive color testing early on would prevent students thinking about vocations such as weaving or painting – or, of course, rail work – from failure later on: a service "of practical value to the community as well as to the individuals."<sup>102</sup> Indeed, Jeffries went on to quote the eminent German physiologist, Rudolph

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<sup>100</sup> Emmet Welsh, "Color Blindness," pp. 8-11.

<sup>101</sup> Benjamin Joy Jeffries, "Report on the Examination of 27,927 School Children for Color-Blindness," *School Document No. 13*, Boston: Rockwell and Churchill, 1880, on pg. 5.

<sup>102</sup> Jeffries, "Report on the Examination of 27,927 School Children for Color-Blindness," on pg. 5.

Virchow, to the effect that finely-honed perception was a necessary component of scientific work – a type of labor that Jeffries certainly viewed as essential to the development of American society. And indeed, as Jeffries would've been aware, Scottish physician George Wilson, author of an 1855 manual on color blindness, had become interested in the condition after noticing that many of his chemistry students failed to correctly discern the products of reactions in the lab. This said, Jeffries stopped far short of recommending legislation to test for color acuity among physicians and scientists. In 1880 he tested 465 of his peers, and found, unsurprisingly, about the same rate of color blindness among physicians as rail workers and schoolchildren. Nevertheless, he noted, his goal was simply to ascertain “the proportion who are colour-blind ‘among those who lack neither education, observation, or cultivation’ – and he eschewed any recommendation for practical action against his peers, in spite of what would seem to be important implications for the practice of science and medicine.<sup>103</sup>

Nor were railroad workers the only individuals who could prove difficult to test. At least initially, Jeffries ascribed to women an uncanny ability to outmaneuver color acuity tests, as evidenced by the remarkable disparity in color blindness diagnoses between men and women. Whereas roughly four percent of (white) men seemed afflicted with color blindness, the figure for women varied between .1% and .01%. In his 1877 report to the Massachusetts State Board of Health, Jeffries attempted to explain this disproportion by suggesting that women were not, in fact, less prone to color blindness, but were simply more adept at hiding their condition.

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<sup>103</sup> Benjamin Joy Jeffries, “Colour-Blindness Amongst the Medical Profession,” *the British Medical Journal*, 31 July 1880, pp. 165-166, on pg. 165.

“It has frequently been said,” he told the Board, “that color-blindness was less frequent among females than males. This is probably incorrect, and has to do with the fact that such a defect is of more importance with the female sex, and therefore more carefully concealed.”<sup>104</sup> Jeffries’s contemporary and John Dalton’s biographer, British physician, Henry Lonsdale, expanded on the importance of refined color perception to women, remarking on the “general reluctance on the part of women to admit of either a moral or physical weakness touching their personal attributes, or calculated in any way to affect their matrimonial prospects.”<sup>105</sup> Nevertheless, as troubling as the specter of a five percent increase in unmarried, color-blind women might be, for Jeffries, anyway, it appeared preferable to the possible inversion of gender roles implied by a population of “normal-eyed” female workers. “[F]uture statistics,” Jeffries predicted, “based on true methods of testing, will reverse the now quite general impression as to [women] having better color-impression, and hence to be preferred, where admissible, as railroad employés [sic].”<sup>106</sup> The importance of establishing foolproof methods of testing color testing was not simply a matter of safety, but also of solidifying the meaning of color perception to a proper balance of gendered labor.

### Legislation and Expedition

Perhaps unsurprisingly, given the adversarial tone of their examiners, many railroad men experienced testing as stressful, nonsensical, and illegitimate.

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<sup>104</sup> Jeffries, “Dangers Arising from Color-Blindness,” on pg. 124.

<sup>105</sup> Henry Lonsdale, *The Worthies of Cumberland: John Dalton* (London: George Routledge and Sons, 1874) on pg. 117.

<sup>106</sup> Jeffries, “Dangers Arising from Color-Blindness,” on pg. 124.



Following the passage of legislation of 1880, all of Connecticut's railroad men were tested using Holmgren's methods. "Instances were related," wrote one commentator, "in which persons whose vision was entirely normal, were unable to pass the examination, simply from nervousness, and one man fainted entirely away under the ordeal."<sup>107</sup> Experienced railroad men found themselves out of work in spite of stellar reputations. As one inspector noted in *the New York Sun*, his company was "constantly surprised at finding that some of our most careful engineers, men who had driven engines for years without any accident that could be traced to mistaken signals, were affected."<sup>108</sup> Nevertheless, he continued, "[w]hen an old employé fails, we try to find him something to do in some other department, but there is little hope of his staying long at the business." In 1892, railroad men in Michigan threatened to strike when four of their coworkers were dismissed for "alleged color blindness."<sup>109</sup> Similar actions were threatened in northern New York in 1885, when workers complained that "only an expert in color could distinguish the shades submitted to them."<sup>110</sup> Indeed, as late as 1935, the *Chicago Daily Tribune* reported on a rail worker who committed suicide after having been removed from his job as an engineer and placed in a switching yard when it was discovered that he was color blind.<sup>111</sup> The man had been on the job for thirty-two years, reported the article; so he would have been familiar with the conflicts over color blindness testing earlier in the century – and indeed, may have even managed to pass

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<sup>107</sup> Kirkman, *Railway and Train Station Service*, on pg. 85.

<sup>108</sup> "Peculiar Freaks of Color Blindness," *Los Angeles Times*, on pg. A15.

<sup>109</sup> "A Season of Strikes: Color Blindness May Cause a Big Walkout of Trainmen," *Los Angeles Times*, 16 Aug 1892, on pg. 2.

<sup>110</sup> "Object to Being Examined for Color-Blindness," *Los Angeles Times*, 29 April 1885, on pg. 1.

<sup>111</sup> "Trainman Goes Colorblind; Shifted from Job; Ends Life," *Chicago Daily Tribune*, 16 May 1935, on pg. 18.

Holmgren's test. His particular response was unusual, but his peers felt a similar sense of frustration and subjugation in the face of the tests. "It is hard on them," admitted the inspector.<sup>112</sup>

At the same time as they threatened to strike over the seeming meaninglessness of the tests, workers also attacked the tests themselves as poor measures of objective vision. In an article in the *Boston Medical and Surgical Journal* (translated by Jeffries) Holmgren had claimed that it was "not only possible to decide how the color-blind see colors, but scientific and objective proofs can also be given."<sup>113</sup> He claimed to have done this by finding people who were color blind in just one eye and testing each eye by use of his worsteds. Again, though, Holmgren emphasized that he did not let his subjects *describe* the sensations they experienced, since "words are less important than acts and [...] description is always less accurate than an objective representation" – like, for instance, the objective representation gleaned by Holmgren through his worsteds test.<sup>114</sup> In the face of this sort of investigation, at least one railroad worker was skeptical. "The truth," he said, "is the agitation [for color blindness testing] has arisen from the difficulty the normal eyed investigators have in understanding exactly what we, the color blind, really see. We could tell them that although the red and green lights do not give us the true red and green sensation, yet still they are strongly contrasted to us and we are in no danger of mistaking one for the other."<sup>115</sup> Nor was this criticism limited to railway workers.

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<sup>112</sup> "Peculiar Freaks of Color Blindness," *Los Angeles Times*, on pg. A15.

<sup>113</sup> A.F. Holmgren, "How the Color-Blind See Colors," *Boston Medical and Surgical Journal*, 2 Jun. 1881, pp. 510-511, on pg. 510.

<sup>114</sup> *Ibid.* on pg. 511.

<sup>115</sup> Quoted Kirkman, *Railway and Train Station Service*, on pg. 83. As a measure of the difference in shared stock of knowledge at the time (or perhaps just insufficient proofreading and homonymous

Physician W.B. Harlow, writing in *Science*, noted that he was capable of passing Holmgren's test although he couldn't distinguish cherries or strawberries on their respective plants, and remarked, "I have always believed that the defect of color-blindness could be accurately described only by one who, like myself, is subject to the peculiarity."<sup>116</sup> For these observers, Holmgren's tests did little to truly, as Holmgren put it, "ascertain a subjective sensation from an objective expression."<sup>117</sup> Indeed, such tests might even obscure the truth. Rather than allowing color blind patients to "tell" their examiners about the status of their internal, private perceptions of reality, the very protocol of the test forced the men to remain mute, picking from colors that did little to reflect what they might otherwise describe as the reality of their sensational worlds.

In more and less obvious ways, color blindness research was a flashpoint for questions about the correct way to judge matters of perception, knowledge, and the proper organization of modern American society. Regulations for color acuity on railroads, for instance, became a political issue in the last decades of the nineteenth century. By the late 1880s, a number of railroad companies across the United States had voluntarily implemented color acuity testing for relevant employees. These efforts, however, were largely piecemeal and their efficacy difficult to judge. The Southern Pacific Railroad, which covered much of the west coast of the United States, implemented color blindness and hearing tests in 1893. However, the

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slippage) Kirkman consistently conflates Helmholtz and Holmgren, writing, for instance, that Helmholtz was a famous Swedish physiologist who was dispatched by the king of Sweden to root out color blindness from the Swedish rail system.

<sup>116</sup> W.B. Harlow, "Color Blindness," *Science*, XI: 261, 3 Feb. 1888, pp. 57-58, on pg. 58.

<sup>117</sup> Quoted in Jeffries, *Color Blindness*, on pg. 207.

company localized the tests in Oakland, California, which considerably slowed their implementation, and relied on a combination of Thompson's stick and lantern tests to judge their employees' color perception.<sup>118</sup> Such procedures were the norm where voluntary testing was concerned, much to the outrage of Jeffries and his peers, who saw such programs to be less than useless in determining chromatic acuity.

More promising by Jeffries's lights – and more controversial – were actions to establish strict mandatory standards of vision testing through state and federal legislation. Prompted by Jeffries, in 1880 Connecticut became the first state to pass laws specifying procedures for testing key rail workers and penalties for failure to do so: railway men who worked with colored signals were to be tested by Holmgren's method, and companies that hired men who couldn't prove they had passed the test would have to pay fines of \$100 to \$200 per man. The law met with tremendous backlash from Connecticut's railroad men and rail organizations and – seeing an opportunity to make political hay in the year before an election – both Republicans and Democrats scrambled to denounce the law. A revised bill introduced later in the year was diluted to near uselessness.<sup>119</sup> As one congressman put it, “[t]he introduction of color blindness into politics afforded food for merriment, at the expense of the State.”<sup>120</sup> The debacle in Connecticut inspired Massachusetts state legislators later that year to pass a color vision law almost

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<sup>118</sup> See “Eyes and Ears,” *Los Angeles Times*, 22 Sept. 1895, on pg. 3; also “Color-Blindness,” *Los Angeles Times*, 25 Aug. 1899, on pg. 15.

<sup>119</sup> On Connecticut's color blindness regulations see “Connecticut's Best Men,” *New York Times*, 12 Aug. 1880; “Color Blindness in Connecticut,” *Hartford Courant*, 9 Mar. 1880; also Kirkman, *Railway and Train Station Service*, on pg. 85.

<sup>120</sup> On making fun of color blindness and politics, see Benjamin W. Harris, “Speech of Hon. Benjamin W. Harris in the House of Representatives” 18 Feb. 1881, Washington, on pg. 8.

ostentatious in its flimsiness: editorials in the *Boston Daily Advertiser* and the *Boston Medical and Surgical Journal* ridiculed the legislation as a sop to railroad companies; incoming Massachusetts governor John Davis Long scorned the law in his inaugural address as “too loose;” while as far away as California, doctors described the law as “so loosely drawn as to render it nearly worthless.”<sup>121</sup> A revised regulation in 1883 took on more of the tone of the original Connecticut law, in spite of what Jeffries, writing in *Harper’s* magazine, described as “desperate attempts by railroad employés and officials [...] to repeal or nullify it.”<sup>122</sup> Five years later, the fight over color blindness regulations made it to Supreme Court. In the case of *Nashville, Chattanooga and St. Louis Railway Company versus the State of Alabama*, the high court ruled that state regulation of rail workers’ “visual organs” did not violate the commerce clause of the constitution.<sup>123</sup>

On a federal level, attempts to regulate color vision met with a similar mix of theoretical approval and operational ambivalence. In 1883, the newly elected president, Chester A. Arthur, endorsed “the advisability of providing for representation of the United States in any international convention that may be organized for the purpose of establishing uniform standards of measure of color-

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<sup>121</sup> See Transactions of the Medical Society of the State of California during the years 1881 and 1882, Sacramento, Beard and Co, 1882, on pg. 188.

<sup>122</sup> See, *Eleventh Annual Report of the Board of Railroad Commissioners*, Boston, 1880, on pg. 65-66; and “Color Blindness and Defective Sight,” in *Manual for the Use of the Boards of Health of Massachusetts* (Boston: Wright and Potter Printing Co, 1881) on pg. 102 (act listed as PS 112 & 179 Acts of 1883, 125); also “Control of the Dangers from Defective Vision,” *Harper’s New Monthly Magazine*, 68:408, May 1884, on pp. 864-868, on pg. 864.

<sup>123</sup> See *Interstate Commerce Reports, Vol II: Decisions and Proceedings of the Interstate Commerce Act of February 4, 1887 together with all Decisions of the Courts relating to Interstate Commerce with Notes, June 1888 to May, 1890* (Rochester, NY: Lawyer’s Cooperative Publishing Co, 1890) pp. 238 – 241, on pg. 239.

perception and acuteness of vision.”<sup>124</sup> Arthur’s call found some enthusiastic supporters in congress, such Massachusetts representative Benjamin W. Harris, who remarked to the house that “[m]odern discovery and science furnish us the means of averting these perils [i.e. of color blindness] in the future, and we shall be remiss in our duty if we fail to adopt and use them.”<sup>125</sup> Starting in August of 1879, the U.S. Department of War decreed that all army recruits would be examined for color blindness, and the departments of the Navy and the Marine Hospital Service shortly followed suit. The Treasury Department, meanwhile, took steps to insure the color vision of commercial sailors.<sup>126</sup> Nevertheless, as of 1900, the Interstate Commerce Commission, perhaps responding to the Supreme Court’s *Alabama* decision, recommended that regulation of color vision was a matter for states, and not the federal government.<sup>127</sup> As for extant national regulations, they often seemed rife with lax testing standards and ineffective administration. For instance, as Harris complained to congress, “[t]he Treasury department yielded to the pressure brought to bear to retain defective [boat] pilots in their places, and allowed them to be re-examined by inspectors of steamboats with signal lights and flags, even after being reported by the medical officer as partially color-blind.”<sup>128</sup> Similarly, Jeffries complained that “[i]n the army [...] [the] color-blind are not rejected except for the signal corps. In the navy, officers and men are examined, with a very recently

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<sup>124</sup> Quoted in Jeffries, “Control of the Dangers from Defective Vision,” on pg. 868.

<sup>125</sup> Benjamin W. Harris, “Speech of Hon. Benjamin W. Harris in the House of Representatives” 18 Feb. 1881, Washington, on pg. 18.

<sup>126</sup> “Colour Blindness in the United States,” *Journal of the Society of Arts*, Sept 17, 1880, pp. 837- 838, on pg. 837. See also Jeffries, “Control of the Dangers from Defective Vision,” on pg. 865

<sup>127</sup> “Regulating of Labor,” *Los Angeles Times*, 26 May 1900, on pg. 12.

<sup>128</sup> Benjamin W. Harris, “Speech of Hon. Benjamin W. Harris in the House of Representatives” 18 Feb. 1881, Washington, on pg. 8.

suggested standard of visual power, but no measured standard of color perception. In the revenue marine service [color testing proceeds] under no definite and required standards."<sup>129</sup> Regulating color sensations required no small amount of political will.

But there was also a more abstract sense in which color perception was a political matter. Holmgren and Jeffries agreed with Rood's suggestion that what people saw, what people knew, and how they made decisions was closely intertwined. "Since we cannot control the subjective perception of another person we cannot prove that all normal-eyed see colors alike," wrote Holmgren (Jeffries translating). "It may, however, be granted that, at least in reference to the principle colors, their quality is the same for all those who entirely agree in reference to them. *There could not otherwise be any question of color between two individuals, just as there could be no intellectual agreement between man and man, if the functions of the senses were essentially different in the two.*"<sup>130</sup> Similarly functioning senses were the basis of civil agreement; it followed, therefore, that dissimilarly functioning senses implied the potential for broad differences in what was assumed to be proper taste, behavior, and even social order. Yale psychologist Edward Scripture, for instance, found discrepancies in perception to be a reasonable explanation for the artistic and sartorial understatement practiced by Quakers, whose communities were believed to have higher-than-average incidences of color blindness. "It is quite probable that [in its distant past] Quakerism would be very likely to attract to itself not only those who were lacking in instinct for the beautiful, but also those actually color blind,"

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<sup>129</sup> Jeffries, "Control of the Dangers from Defective Vision," on pg. 864.

<sup>130</sup> Holmgren, "How the Color-Blind See Colors," on pg. 510.

reasoned Scripture. “The productions of many of our artists must appear actually hideous to color-blind persons who cannot tell the difference in color between a strawberry and its leaves.”<sup>131</sup> Without such a communal abnormality of vision, Scripture wrote, the Society of Friends would have never evolved its plain customs – after all, to turn one’s back on “the soul-stirring artistic productions” of the rest of society “would be treason to the instincts that God planted in [human kind].”<sup>132</sup>

Scripture’s theory represented a relatively benign and uninflected example of how notions “the functions of the senses” impacted – and were impacted by – ideas about the proper organization of society. Among the more prevalent questions raised by researchers interested in color blindness was the incidence of color blindness in non-whites, and particularly in “primitive” cultures. At least since Alexander von Humboldt’s 1845 account of the great visual acuity of South American Indians in his *Kosmos*, an abiding opinion held that “primitive” or “non-civilized” people had more refined senses than their “civilized” peers.<sup>133</sup> This view found its apotheosis in Herbert Spencer’s influential 1876 essay, “The Comparative Psychology of Man,” in which the British philosopher and sociologist – proceeding from the assumption that this fine sensory acuity among “non-civilized” people was, indeed, a matter of fact – proposed that it came at the cost of lesser mental

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<sup>131</sup> Edward Wheeler Scripture, *Thinking, Feeling, Doing* (Meadville: Flood and Vincent, 1895) on pg. 178.

<sup>132</sup> Scripture, *Thinking, Feeling, Doing*, on pg. 179.

<sup>133</sup> W.H.R. Rivers puts Humboldt’s account as one of the first to put forth the thesis that non-whites have more advanced visual acuity in *Reports of the Cambridge Anthropological Expedition to the Torres Straits* (London: J. Clay and Sons, 1900) on pg. 12.



function.<sup>134</sup> In this view, apprehension of the world was a zero sum game between sensory input and cognitive acumen – non-civilized people could afford to have enhanced senses because they did not spend their limited mental energies thinking about the things that civilized people did, such as aesthetic beauty, higher mathematics, justice, civic organization and so forth. Spencer's theories of racial and cultural superiority found a receptive audience in the United States in the late nineteenth century – a society struggling to come to grips with the reconstruction of racial order in the north and the south; with fears of (white) racial degeneration in the face of rising tides of immigration; with continental expansion and the assimilation and extermination of non-white residents of the American west; and – in the last years of the century – with the social implications of an expanding overseas empire.<sup>135</sup> Variability of color sense made an excellent template for the *scientific* discussion of how members those races who increasingly seemed to be exceeding their place might be repositioned in modern American society. Discussing the low incidence of color blindness in women, an article in *the New York Times*, written in response to Jeffries's *Color Blindness*, joked, "[i]t has to be conceded, at the outset, without the least reservation, that the ladies are in this respect quite 'out

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<sup>134</sup> Although published originally in *Mind*, Edward Youmans, the editor of *Popular Science Monthly* and a friend of Spencer's, reprinted "The Comparative Psychology of Man," in *Popular Science Monthly*, January 1876, 257-269; also in Spencer, *Essays: Scientific, Political and Speculative*, Vol 1 (New York: D. Appleton and Company, 1891) pp. 351- 370.

<sup>135</sup> The classic assessment of Spencer in America is Richard Hofstadter's *Social Darwinism in American Thought* (Boston: Beacon Press, 1992: 1944) pp. 31-50; for an interesting – if perhaps not characteristic – account of Spencer's influence in America, see John White, "Andrew Carnegie and Herbert Spencer: A Special Relationship," *Journal of American Studies*, 13: 1, Apr. 1979, pp. 57-71; Lee D. Baker gives a curt if reasonably satisfying account of Spencer's uptake into nineteenth century American elite thought in *From Savage to Negro: Anthropology and the Construction of Race, 1869 – 1954* (Berkeley: University of California Press, 1998) pp. 26-31; it is worth mentioning that the term "social Darwinism" is not unproblematic, as described by – among others – R. J. Halliday, in his "Social Darwinism: a Definition," *Victorian Studies*, 14:4, Jun. 1971, pp. 389-405.

of sight' the superiors of men." But – and here the article turned serious – “this argument must not be accepted too hastily as proving the superiority of woman; for it equally proves the superiority of the negro.”<sup>136</sup>

At least initially, more serious researchers, too, proceeded from the perspective advanced by Humboldt (and later, Spencer) albeit with a degree of measured skepticism. Benjamin Gould, for instance, reported in his *Investigations in the Military and Anthropological Statistics of American Soldiers* of 1869 that, among members of the Union Army tested, “the proportionate number of color-blind found among the full black, or among the Indians, is not more than one half as great as among the white men.” Gould had to admit, though, that given the fact that only a quarter as many non-whites had been tested as whites (who, not incidentally, were indexed in the schedule of statistics as “Soldiers,” “Sailors” and “Students,” rather than the “Full Blacks,” “Mulattoes” and “Indians” of the other men tested) it was unclear “how far [this] apparent immunity from color-blindness may be the result of insufficiency in the number or thoroughness of the examinations.”<sup>137</sup> Likewise, Jeffries qualified statistics that seemed to show color blindness to be about half as common among black male students as white males in Washington D.C. schools, noting that “[t]his smaller percentage among the boys may be due to various causes aside from the difference of race. Moreover, larger numbers may entirely change it.”<sup>138</sup>

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<sup>136</sup> “Color Blindness,” *New York Times*, 30 Nov. 1879, on pg. 4.

<sup>137</sup> Gould, *Investigations in the Military and Anthropological Statistics of American Soldiers*, on pg. 548.

<sup>138</sup> Jeffries, *Color Blindness*, on pg. 68.

Later researchers were less measured in their conclusions – particularly when testing American Indians in the Eastern and Midwestern United States. In 1882, at the Carlisle Indian Industrial School in Carlisle, Pennsylvania, L. Webster Fox tested the color acuity of 161 men and 89 women from “twenty seven different [American Indian] tribes,” using Thompson’s stick.<sup>139</sup> Of the 250 people tested, Thompson found that three – two Cheyenne half-brothers and a Sioux man – were color blind (or approximately 1.8% of the male population of the test takers). In a similar 1889 study, University of Kansas physicists Lucien Ira Blake and William Studdards Franklin tested 285 men and 133 women – again of “many tribes” – at another “Indian Industrial Training School,” the paramilitary Haskell Institute in Lawrence, Kansas. Their results – this time obtained using Holmgren’s worsted test – were even more striking: a .7% color blindness rate among the people they tested.<sup>140</sup>

Perhaps the most influential color tests along these lines were those performed by W.H.R. Rivers, a British anthropologist and psychologist, during an expedition to the Torres Straits Islands in 1898. Rivers and his team took along a set of Holmgren’s wools, and endeavored to discern the color acuity of the inhabitants of the islands of the Fly River delta in New Guinea, and the islands of Mabuia and Murray Island in the Torres Straits. As much as possible, Rivers attempted to follow Holmgren’s protocol, refusing, for instance, to acknowledge indigenous color names until after the test had been completed, lest the naming of the colors influence the

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<sup>139</sup> L. Webster Fox, “Examination of Indians at the Government School in Carlisle, PA. for Acuteness of Vision and Color-Blindness,” *Medical Times*, Feb 25, 1882, on pg. 346.

<sup>140</sup> L.I. Blake and W.S. Franklin, “Color-Blindness a Product of Civilization,” *Science*, 13:317, 1 Mar 1889, pp. 170-171 on pg. 171.

test taker's performance on the examination. Examinees were shown the pile of wools and the control strands, and, Rivers reported, understood what they were being asked to do with little instruction – the sole exception being a man from Kiwai Island in the Fly River delta named Emabogo, who seemed at first to be red-green blind, though Rivers subsequently decided that he simply failed to comprehend the point of the test. "Altogether," reported Rivers, "in Torres Straits and the Fly River district of New Guinea, 152 individuals were tested of whom 130 were males. With the just possible exception of Emabogo, there was not a single case of red-green blindness, although this condition exists in about 4 per cent. of the male European population. This can hardly be due to chance, and I think the number examined is sufficiently large to justify one in saying that this form of colour-blindness is either absent in this race, or much rarer than among European populations" – a fact which, he noted, gibed with the work of Fox and others.<sup>141</sup> He did note, on the other hand, a striking lack of affinity for blue and green shades among the islanders, leading him to consider that "there was more reason to suspect the existence of yellow-blue blindness, rare as that condition is among Europeans"<sup>142</sup> In all, Rivers concluded that "colour-blindness may be a characteristic of certain races and the existence or absence of this defect may help us in the difficult task of deciding on ethnic affinities."<sup>143</sup>

Theories of "ethnic affinity" based on sensory acuity easily transitioned into theories about affinities for particular sorts of social organization. From their tests,

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<sup>141</sup> W.H.R. Rivers, *Reports of the Cambridge Anthropological Expedition to the Torres Straits*, on pp. 52-53.

<sup>142</sup> *Ibid.* on pg. 51.

<sup>143</sup> *Ibid.* on pg. 94.

Blake and Franklin, for instance, reasoned that “defective color-vision is in some way the product of civilization” – noting that, “[t]he law of heredity indicates increasing sensitiveness in those nerves which are subjected to special use through many generations.”<sup>144</sup> Indeed, Blake and Franklin felt they had found several intermediary cases, in which, though no color blindness *per se* could be detected, “half-breeds showed more instances of blunted color-sense than the full-bloods” – in other words, those who were halfway civilized were only inclined to a sort of halfway color blindness.<sup>145</sup> Fox made a similar, if somewhat less clearly-articulated claim, when he remarked that “[t]he acuteness of vision of nomadic tribes has long been noted. [Among test subjects] the few that were deficient were found among the semi-civilized Creeks.”<sup>146</sup> He complicated this analysis, however, noting that “color-blindness is associated with an inferior average of intellectual power among whites,” such that color blindness was far less frequent among “Eton College boys” than those of lesser social standing – a blithe, if confusing, conflation of class, race, education, and intelligence.<sup>147</sup> As for Rivers, his research led him to the conclusion that “the visual acuity of savage and half-civilized people, though superior to that of the normal European, is not so in any marked degree.”<sup>148</sup> Nevertheless, he could not help but note the essential truth of Spencer’s hypothesis, remarking that it made sense that savages had different mental lives from Europeans since “[i]f too much

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<sup>144</sup> Blake and Franklin, “Color-Blindness a Product of Civilization,” on pg. 171.

<sup>145</sup> *Ibid.*

<sup>146</sup> L. Webster Fox, “Examination of Indians at the Government School in Carlisle, PA. for Acuteness of Vision and Color-Blindness,” *Philadelphia Medical Times*, Feb 25, 1882, on pg. 347.

<sup>147</sup> *Ibid.* on pg. 346.

<sup>148</sup> W.H.R. Rivers, *Reports of the Cambridge Anthropological Expedition to the Torres Straits*, on pg. 42.

energy is expended on the sensory foundations, it is natural that the intellectual superstructure should suffer.”<sup>149</sup>

This notion – that color sense was inversely proportional to cognitive ability– did not go unchallenged, particularly in the early twentieth century. Psychologist Robert S. Woodworth, writing in 1910, argued against the “common opinion” that “savages are gifted with sensory powers quite beyond anything of which the European is capable.”<sup>150</sup> Woodworth acknowledged that red-green blindness might be a “reversion to a more primitive state of the color sense,” but noted that, since no “race of men” was proven to be consistently red-green blind, “the development of a color sense substantially to the condition in which we have it, was probably a pre-human achievement.”<sup>151</sup> Conveniently, Woodworth, a new hire at Columbia University, had recently been placed in charge of handling Columbia’s contribution to the psychometric and anthropometric displays in the United States’ portion of the 1904 St. Louis World’s Fair – an exhibition which included representatives of “savage” peoples from the recently-occupied Philippines, as well as from the Zuni, Kikapoo, and Cheyenne Indians of North America – all of whom lived on-site in intricate simulacra of their “natural” environments.<sup>152</sup> Surveying these living exhibits, Woodworth had the opportunity to conduct his own tests on the perceptual acuity of non-whites, and the results he obtained sharply contradicted

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<sup>149</sup> *Ibid.* on pg. 44-45.

<sup>150</sup> R.S. Woodworth, “Racial Differences in Mental Traits,” *Science*, 4 Feb. 1910, 31: 788, pp. 171-186, on pg. 174.

<sup>151</sup> *Ibid.* on pg. 178-179.

<sup>152</sup> On Woodworth at the World’s Fair, see Robert S. Woodworth, “Robert S. Woodworth,” in C. Murchison, Ed., *A History of Psychology in Autobiography*, Vol 2 (Worcester, MA: Clark University Press, 1930) pp. 359-380, on pg. 373; also G. Richards, *Race, Racism and Psychology: Toward a Reflexive History* (New York: Routledge, 1997).

the established doctrine. "We were able, at St. Louis," he reported, "to try on representatives of a number of races a difficult color matching test, so different indeed from that of Rivers that our results cannot be used as a direct check on his." Though he did not specify his test methodology, Woodworth concluded that, while "all other races were inferior to whites in their general success in color matching [...] [o]n the whole, the color sense is probably very much the same all over the world."<sup>153</sup> Indeed, he continued, "[w]hen our measurements are all obtained and spread before us, they convey to the unaided eye no clear idea of a racial difference, so much do they overlap."<sup>154</sup> This suggested to Woodworth several serious limitations in the scientific study of the inner lives of human beings. For one thing, he wrote, "our inveterate love for types and sharp distinctions is apt to stay with us even after we have become scientific, and vitiate our use of statistics to such an extent that the average becomes a stumbling block rather than an aid to knowledge."<sup>155</sup> For another thing, he pointed out, the very physical bases of color acuity testing were likely flawed: "[w]e may suppose [...] that all of our tests, founded as they are on material which is familiar to us, will be more or less unfair to peoples of very different cultures and modes of life."<sup>156</sup>

Woodworth was not the only one to voice doubt – for his part, Edward B. Titchener, a prominent American psychologist, was similarly pointed in his 1916 reconsideration of Rivers's work. "I suppose that field-work in psychology has never been done under better conditions," he told the American Philosophical

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<sup>153</sup> R.S. Woodworth, "Racial Differences in Mental Traits," on pg. 174.

<sup>154</sup> *Ibid.* on pg. 172.

<sup>155</sup> *Ibid.*

<sup>156</sup> *Ibid.* on pg. 174.

Society, and yet, “the impression left my own repeated reading [of the Torres Straits Report] is that the tests were inadequate to their purpose.”<sup>157</sup> Titchener’s criticisms were wide-ranging, but they boiled down to a basic question: was the Holmgren test really a satisfactory measure of color as an absolute, abstract, and universal quality of perception? Titchener thought not, and suggested that Rivers’s own data proved it. “We [i.e. Europeans and Americans] are so accustomed to classify [sic] colored objects by their hue, their ‘color’ proper, that the classification seems to us to be natural and normal.”<sup>158</sup> This was, however, manifestly not the case with the people Rivers had tested. As Titchener pointed out, Rivers himself had noted that individuals would frequently murmur words denoting relative chromatic saturation as they categorized their wools – as when Rivers commented, “[o]ne could often hear a native saying *kakekakekek* [or “white”] to himself as he picked up a colorless wool to place with the green.”<sup>159</sup> As a strict adherent to Holmgren’s method, Rivers considered this evidence of a linguistic corruption of the test – the results were a “fallacy of nomenclature.”<sup>160</sup> However, Titchener pointed out, this same “fallacy of nomenclature” could account for the apparent prevalence of yellow-blue blindness. Titchener quoted Rivers’s remark that “the yellow test wool used by me was a dull yellow,” then triumphantly pointed out that Rivers had similarly said that “blue is also regarded by the natives as a dull color.”<sup>161</sup> Thus, hypothesized Titchener, rather

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<sup>157</sup> E.B. Titchener, “On Ethnological Tests of Sensation and Perception with Special Reference to Tests of Color Vision and Tactile Discrimination Described in the Reports of the Cambridge Anthropological Expedition to Torres Straits,” *Proceedings of the American Philosophical Society*, 55: 3, 1916, pp. 204-236, on pg. 204.

<sup>158</sup> *Ibid.* on pg. 228.

<sup>159</sup> Rivers, quoted *Ibid.* on pg. 230.

<sup>160</sup> W.H.R. Rivers, *Reports of the Cambridge Anthropological Expedition to the Torres Straits*, on pg. 46

<sup>161</sup> Titchener, “On Ethnological Tests of Sensation and Perception,” on pg. 205.



than displaying a racial predisposition to yellow-blue blindness, Rivers's test-takers were simply displaying a cultural predisposition towards categorizing colors along many different axes – not simply hue, but perhaps brightness or saturation as well.<sup>162</sup> Indeed, seen in this light, not only was Rivers's test design flawed, but his insistence on hewing to Holmgren's rule that subjects refrain from speaking had forced him to overlook important data. Titchener had nothing to say one way or another about theories that linked color vision to cognition, but he did note that Rivers's reports from the Torres Straits, "remind us, time and time again, that human nature is much the same the world over."<sup>163</sup>

### Conclusion

Anxiety about the nature of sensory perception in modern society united political debates about color acuity tests for railroad workers and scientific debates about the correct method of conducting perceptual testing on members of non-European civilizations. Could the perception of color be divorced from lived experience – could it be abstracted, notated, even universalized? Or was perceptual experience contingent upon the material and cultural surroundings of the observer? Jeffries and Holmgren – in line with Spencer and his adherents – believed in an uncontextualized truth of perception: the best way to understand vision was to abstract it from the world of lived experience. "Culture" as such, was an intellectual activity – not a sensual one. Culture was a community, that is, built on a commitment to the viability of sensation in the abstract. For the later theorists Woodworth and Titchener, such a

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<sup>162</sup> *Ibid.* on pg. 230.

<sup>163</sup> *Ibid.* on pg. 206.

notion of culture and community was illusory – the senses were tied to the material and linguistic forms on which they were based. These were, moreover, exactly the sorts of questions that motivated the more literally political battles surrounding color blindness testing of rail employees. The proximate issue that concerned rail companies and employees facing mandatory color blindness testing were, of course, ones of cost (personal and corporate); but those who resisted perceptual testing did so not on *economic* grounds, but rather on the grounds that vision was contextual – a matter of what, exactly, one was looking at, and how they were looking. In this sense, battles over both vocational color testing and anthropological color testing were also always battles over the nature of perceptual *culture* – particularly in Jeffries’s sense of “culture” as a type of communally shared knowledge. For Jeffries – as well as Spencer and his followers – cultural knowledge predicated on science assumed a hierarchical form, administered by experts, who could give more honest accounts of the perceptual lives of non-experts than they themselves. For Woodworth and Titchener – as well as railroad employees who doubted that color testing was any aid to determining what they really saw – color knowledge (and, indeed, one might say, color culture) was precisely not capable of being broken down into component parts with any lasting verisimilitude.

In May of 1935, the *American Weekly*, a popular supplement to many newspapers, published a series of full color reproductions of a new variety of color acuity tests, along with the caption, “Are you Color Blind? This will Tell You.” The tests, first published in 1917 by Shinobu Ishihara, a Japanese ophthalmologist, had since the

1920s been growing in popularity in the United States, both because of their convenience, and their relative sophistication. The test was a series of carefully-printed color plates, in which a letter – or sometimes a shape – composed of tiny circles was hidden within a larger field of tiny circles (see figure 3.7). The circles that constituted the letters and the ones constituting the shapes were printed in different shades of contrasting control and confusion colors; an observer with a nominally full gamut of color vision would be able to discern the letter (or, if illiterate, trace the shape with her finger); a color blind observer would see only a field of circles in roughly similar hues. Along with images of the test plates, the article supplied the “answer” as well as the corresponding diagnosis if a reader could not see the embedded letter.

At least for some members of the scientific community, the publication of the Ishihara tests was a blow to science. In a sharply worded editorial in the *American Journal of Psychology*, Elsie Murray, a psychologist at Cornell University, complained that the publication of the tests in a popular journal compromised their viability. On the one hand, she noted – quite in line with Holmgren – that the tests were supposed to be shared only among physicians, to prevent deceivers from learning the tests beforehand and simply reciting what they believed to be the correct letter. “[A]n easily memorized key,” she warned, “is now available to the hundreds who have long sought it.”<sup>164</sup> More importantly, though, the publication of the test undermined professional authority. The tests were printed on cheap paper, with an inexpensive process, and thus the circles of color in the *American Weekly* bore a

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<sup>164</sup> Elsie Murray, ““The Ishihara Test for Color-Blindness: A Point in Ethics,” *The American Journal of Psychology*, 47:3, July, 1935, pp. 511-513, on pg. 513.

substandard resemblance to the carefully-calibrated prints of the approved Ishihara plates. When people who had self-diagnosed based on the faulty popular prints (which, in any event, came with no warnings about proper lighting or viewing distance) were tested on the real thing, Murray cautioned, “[m]any [...] able to make a fair showing with this copy will now maintain their cases have been unfairly diagnosed by the clinician.”<sup>165</sup> Furthermore, what little copy within the article there was to explain the test was woefully unscientific, thus adding to the misinformation, which the interested public could now foist on their physicians. “Thus,” Murray argued, “overnight, the test fell from the level of a scientific instrument – invaluable in preliminary diagnosis in the medical office, in universities, in the army, in the navy, and in aviation – to the status of a parlor diversion, on par with the crossword puzzle, or ‘Ask me another.’”<sup>166</sup>

And yet, the publication of the Ishihara test in a very colloquial popular journal can be seen in quite another light – not as a blow to color science, but as its ultimate victory. Color blindness was no longer a strange disorder whose existence was indescribable if not debatable; color as an abstract perceptual quality could no longer be reasonably contested. Indeed, the very quality that irked Murray most was a measure of the complete success of two generations of color blindness initiatives: the scientific measure of chromatic acuity was a matter of everyday life – even everyday entertainment. By the early twentieth century, color blindness testing could be spoken of as *de rigueur* for a stunning variety of fields. With no apparent irony, a 1941 article told of a young man whose ardent wish was to be an

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<sup>165</sup> *Ibid.* on pg. 512.

<sup>166</sup> *Ibid.* on pp. 511-513.

accountant. While in school he realized that he could not tell red entries from black, but was assured by an advisor unfamiliar with color blindness that everything would work out okay. Big mistake. He met with problems. The young man, the article concluded, “might have been happier and more successful in another commercial line, which had no color signals.”<sup>167</sup> No longer the sole concern of railroad engineers, scientific determination of color acuity was needed in a wide variety of vocations.

In the present day United States, testing for color blindness is an unremarkable component of the usual battery of physical examinations that one encounters with greater or lesser frequency in the course of receiving early childhood medical exams, school physicals, and entry testing for certain vocations. The results of the test – while in some cases damaging to an individual’s goals or aspirations do not carry with them lasting stigma; the socio-cultural “meaning” of color blindness is now deeply obscure.<sup>168</sup> This was manifestly not the case for the late nineteenth century science of Jeffries and others of his medical peers, who found in color blindness not simply a matter of different physiology or psychology, but also of different possible configurations for modern American society. The very commonness of color blindness testing and diagnoses speaks to the degree to which Jeffries and his peers were successful in linking everyday perception of color to a regime of scientific testing which valued theoretical constructions of color as much –

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<sup>167</sup> Emily C. Davis, “A New Color-Blindness Test,” *Science News Letter*, 21 June 1941, pp. 390 to 391; 397, on pg. 390.

<sup>168</sup> Though, in the 2003 film, *Little Miss Sunshine*, color blindness is the cause of profound distress for one character, who becomes deeply upset when he realizes he is color blind and must give up his obsession with becoming a pilot.

or more – than the lived experiences of those perceivers. That Americans now experience less epistemological conflict than Jeffries and his peers over the nature of measuring and testing color acuity is the testimony not of a denuded sense of appreciation of color, but rather of the degree to which a highly ritualized and richly meaningful chromatic practice has been internalized in mainstream institutions and consumer culture.

## 4

### **Before Basic Color Terms: The Ornithologist, the Priest, his Printer, and the Logician**

#### **Introduction**

In 1901, a year after W.H.R. Rivers returned to England from studying the color vision of the “primitive” people of the Torres Straits, an opportunity to continue his research presented itself when a group of “twenty seven Eskimo” arrived in England from Labrador to be displayed at the Exhibition Hall in Kensington, London. Having ingratiated himself with the Labradoreans’ minder, an American named Ralph G. Taber, Rivers joined a duo of anthropologists – a W.L.H. Duckworth and a B.H. Pain – in studying the visitors. While Duckworth and Pain set to work ascertaining the grip strengths and anatomical dimensions of their guests with their anthropometers and craniometers (at points the “thick and somewhat rigid sealskin garments of [the] subjects” evidently frustrated the anthropologists’ efforts to get good measurements) Rivers took out his Holmgren wools and – with the help of one of the party, Esther Enutsiak, who acted as an interpreter – proceeded to administer his color tests. The results surprised him.<sup>1</sup>

Unlike the people that he had examined in the Torres Straits – members of tribes in “stages of civilization similar to that of the Eskimo,” – Rivers’s subjects in

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<sup>1</sup> W.L.H. Duckworth and B.H. Pain, “An Account of Some Eskimo From Labrador,” *Proceedings of the Cambridge Philosophical Society*, X:5, 1900, pp. 286 – 291, on pg. 286; also W.H.R. Rivers, “The Colour Vision of the Eskimo,” *Proceedings of the Cambridge Philosophical Society*, XI:1, 1902, pp. 143 – 149.

London exhibited a profoundly well-developed color sense, as was clear from the precision of their vocabulary for defining color sensations. “The first interesting feature of the Labrador vocabulary,” began Rivers, “is the definiteness of the nomenclature for green and blue” – a distinction not apparent with his subjects in the Torres Straits. Nor did the “Eskimo” tend to confuse blue and black, as had his tropical subjects. Red, pink, yellow, black – all were distinguished and named with ease, as were different shades – a fact all the more surprising, reported Rivers, because the landscape in Labrador was generally devoid of color, except in autumn, and color didn’t play a major role in the Eskimo’s decorative practices. Most surprisingly of all was the methodological elegance exhibited by the visitors’ mode of color naming. “The most characteristic feature of the Eskimo language appears in the colour vocabulary in the very extensive use of qualifying affixes. [...] [A]ll hues, shades, and tints of colour were named by various modifications of the six words for red, yellow, green, blue, white and black.”<sup>2</sup> This indicated to Rivers a “higher psychological development of nomenclature” than other “primitive” peoples, because “it implies the presence of definite abstract ideas about colour”<sup>3</sup> Thus, the study seemed to belie Rivers’s conclusions from the Torres Straits that primitive people *necessarily* experienced primitive color sensations.

In the United States, Rivers’s study attracted the attention of Christine Ladd-Franklin, a logician and psychologist then working from Johns Hopkins University in Maryland. Rather than the way it described the Eskimo’s color vision, however, Ladd-Franklin found River’s article interesting for the way in which it seemed to

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<sup>2</sup> Rivers, “The Colour Vision of the Eskimo,” on pg. 147.

<sup>3</sup> *Ibid.* on pg. 148.



indicate a profound divergence between the ways in which modern *Americans* experienced color – and particularly the ways in which they spoke about these experiences. “This coincidence [among Eskimos],” she wrote,

*of a scientific color scheme with an impersonal character of color experience is certainly very remarkable; it is not simply that the prominent colors have prominent names [...] but that such a perfect reflection of the facts of consciousness should occur with a people who have no occasion to subordinate color as a pure sensation to color as a sign of a definite object.*<sup>4</sup>

Unlike Europeans and Americans, that is, the manner in which Eskimos spoke of color seemed to suggest a pure and unadulterated relationship between the words they used to describe sensations and the sensations themselves – they didn’t mix up objects and colors like English speakers did with terms like “orange,” “olive,” and “violet.”<sup>5</sup> They didn’t have singular words for colors that were actually combinations of two colors, like “purple.” They didn’t invent terms for colors – such as “ashes of roses” or “peacock” – in order to differentiate commercial items. Rather, the nature of their spoken language seemed to reflect precisely the nature of their mental lives, as structured around their fundamental apprehension of visual sensations. It was not, therefore, the colors the Eskimos that *experienced* that interested Ladd-Franklin, but how they *expressed* those sensations, and more importantly, what those expressions revealed about the innermost experiences of not only “primitive,” but also “civilized” observers.

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<sup>4</sup> Christine Ladd-Franklin, “Color-Introspection on the Part of the Eskimo,” *Psychological Review*, VIII: 4, July, 1901, pp. 396 – 402, on pg. 399 (Italics added).

<sup>5</sup> On the history of “orange” as a lexicographically irritating term for both color and fruit see Michael Rossi, “Colors: Orange,” *Cabinet*, No: 41, Spring 2011, pp. 14-17.

This chapter deals with the ways in which different Americans, between 1890 and 1930, came to think through the relationships between objects, sensations and the words used to describe them. If psychophysical experiments and color blindness studies corralled vision – brought it into a rough sort of discipline, drew the subjectivity of the viewer into sharper focus, and sorted the normal-eyed from the sensorially deficient – these studies said little about what, precisely, experiences of color *meant*. How were individuals to speak about color? What precisely did words for colors mean? How was it possible to experience millions of color sensations but define none with accuracy? What did this say about both the nature of vision and the nature of the observer? Turn of the century Americans answered these questions in a variety of ways, each of which framed a different relationship between color science and color in lived experience. This chapter singles out three examples for close scrutiny. Robert Ridgway, an ornithologist at the Smithsonian Institution, attempted to devise a scientific nomenclature of colors for use by naturalists, based on tables of color terms carefully, if ambiguously, keyed to objects. John Henry Pillsbury, a high school botany teacher, and Milton Bradley, a printer and board game magnate, looked to the solar spectrum to introduce standard terms for color in education and manufacture. And for her part, Ladd-Franklin mobilized color terms to argue for a unified theory of vision and mind. All four individuals felt themselves to be invested in the development of the United States as an “advanced,” “scientific” civilization, but each of their approaches to color terms reveals the deep

ambiguity about the status of both vision and color names in nineteenth century society.

Color naming was more than an academic issue for nineteenth century Americans. On the one hand, developments in commercial manufacture and distribution such as aniline dyes, shop windows, and mail order catalogs allowed American consumers access to a flood of goods in bright new colors that seemed to defy description.<sup>6</sup> “Looking back on this year’s riotous abundance” began an 1890 style piece the *New York Times*, “[...] the gamut of color embraces every shade heretofore conceived for feminine adornment, and not a few that were never before on sea, nor land – nor woman”<sup>7</sup> To define colors that had never before been seen required a correspondingly unprecedented degree of linguistic uncertainty. The *Times* poked fun at the ubiquity of the term “Eiffel Red,” remarking, “[i]f any doubtful shade of red with a tone of lavender, lilac, pink, or brown is left undesignated it is unhesitatingly denominated Eiffel red, and so offered to the public who accept it with unquestioning faith. The original motif, if it may be so called, has been so far lost sight of that the true Eiffel red is as difficult to determine as the color of the tower itself.”<sup>8</sup> Meanwhile, “The new red tinted with yellow,” wrote the *Times*, “[...] though called by some Tomato red is better indicated by the yellow-red nasturtium.”<sup>9</sup>

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<sup>6</sup> For an excellent account of popular responses to the ostensible flood of new colors and color-generating technologies see William Leach, *Land of Desire: Merchants, Power, and the Rise of New American Culture* (New York: Vintage, 1993) pp. 39-70.

<sup>7</sup> “New Wool Goods,” *New York Times*, Feb 9, 1890, on pg. 12.

<sup>8</sup> *Ibid.*

<sup>9</sup> *Ibid.*

Some members of the public were, indeed, enthusiastic about the possibilities of new, indefinable colors, though others did not accept them with “unquestioning faith.” On the one hand, in 1897, art critic Sadakichi Hartman – in between writing plays about the erotic adventures of Jesus Christ and the life of Confucius – penned a theatrical biography of Buddha in which the spiritual leader’s enlightenment was to be dramatized by “a concert of self-radiant colors [...] represented by pyrotechny, brought by chemistry, electricity and future light-producing sciences” and culminating in a “kaleidoscopic symphony of color effects constantly changing in elation and depression, velocity, intensity, variety and sentiment [...] at last improvising an outburst of new colors, like ultra red and violet, for which optical instruments have first to be invented before the human eye can perceive and enjoy them.”<sup>10</sup> On the other hand, Francis King, a gardener, was more reserved, following her British peer, Gertrude Jekyll, in decrying the “slip slop” of modern color naming conventions, exemplified by colors like “mauve” which had only within her lifetime come into common use.<sup>11</sup> Indeed, in her volume, *Wood and Garden*, Jekyll warned her readers against color names both new and old, including “crimson” – which, she noted, “is a word to beware of; it covers such a wide extent of ground [...] that one cannot know whether it stands for a rich blood colour or for a malignant magenta.”<sup>12</sup> Magenta was “malignant,” thought Jekyll, because it was a

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<sup>10</sup> Sadakichi Hartmann, *Buddha: a Drama in Twelve Scenes* (New York: The Author, 1897) on pg. 39-41. Thank you to Emily Gephart for pointing out Hartmann’s chromatic fantasy. For a later and infinitely more nefarious fantasy of colors never before seen, impossible to comprehend, and possibly madness-inducing see also H.P. Lovecraft’s 1927 short story, “The Colour Out of Space,” in *H.P. Lovecraft: Complete and Unabridged*, New York: Barnes and Noble, 2008.

<sup>11</sup> Quoted in “Susan W. Lanman, “Colour in the Garden: ‘Malignant Magenta,’” *Garden History*, 28:2, Winter 2000, pp. 209-221, on pg. 214.

<sup>12</sup> Gertrude Jekyll, *Wood and Garden* (London: Longman, Greens, and Co., 1904) on pg. 224.

“new” color – the trade name of a novel aniline dye. In the same way, mauve – another aniline color – served as a symbol for historian Thomas Beer who, titled his 1928 book about the dissolution of American intellectual culture at the turn of the century *The Mauve Decade*, after a quip by the artists James McNeil Whistler that “mauve is just pink trying to be purple.”<sup>13</sup>

Scientists of many disciplines tended to view difficulties in defining colors as a problem that science had wrought, in particular through the industrial production of intensely colored and highly versatile aniline dyes.<sup>14</sup> Ridgway, for instance,

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<sup>13</sup> Thomas Beer, *The Mauve Decade* (New York: Alfred Knopf, 1926). Whistler is quoted only on the title page, which bears the legend, “...Mr. Whistler said: “Mauve? Mauve is just pink trying to be purple...” Beer’s further references to mauve throughout the text are limited – the term is mentioned only twice – once in connection with prostitution, the other with money. Interestingly, Lewis Mumford takes a different chromatic tack in *The Brown Decades*, his 1931 history of reconstruction era society in the U.S. These years, for Mumford, are brown both because the dominant building materials of the decade were brown (brown stone, brown wood panels, brown paintings) and because the spirit of the American people was, for Mumford, brown – ambivalent, muddy, broken by war and greed. Both mauve and brown of course, stand with Mark Twain’s “gilded” age as chromatic similes for folly, excess and shortsightedness with which both period and subsequent commentators tarred the age. (See Lewis Mumford *The Brown Decades: a Study of the Arts in America, 1865-1895* (New York, Harcourt: Brace and Company, 1931); also Mark Twain, *The Gilded Age: A Tale of Today*, (New York: Harper, 1915)).

<sup>14</sup> Aniline dyes derived from coal tar – a viscous, brown byproduct of the process used in the nineteenth century to render coal into gas for lighting. Composed of a complicated array of carbon-based compounds, by the early 1820s, coal tar had attracted the fascination of a burgeoning generation of organic chemists because of the wide range of substances that could be derived through reactions between it and other chemicals. When treated with different reagents, coal tar yielded substances of potential greater commercial usefulness and scientific interest than the industrial sludge from which they derived. Phenols, for instance, were used as anti-microbial agents. Nitrobenzene held potential as a perfume base. And aniline – a derivative of nitrobenzene – had been known since the 1820s to yield brightly-colored precipitates under certain circumstances. Nevertheless, the high cost of distilling aniline from coal tar militated against commercial production of these agents as dyes. It wasn’t until 1856, when William Perkins, a student at the Royal Academy of Chemistry, began to investigate industrial production of a vivid purplish dye that he had stumbled upon while attempting to synthesize quinine, that coal tar dyes began to appear to be viable commercial products. Within three years of the commercial production of the dye that Perkin called “Mauve,” chemists in Britain had taken out twenty-nine patents on different aniline dyes – almost double the number of patents on natural dyes. (William J. Hornix, “From Process to Plant: Innovation in the Early Artificial Dye Industry,” *the British Journal for the History of Science*, 25:1, Mar. 1992, pp. 65-90, on pg. 69). By the 1880s, fuchsine, aniline blue, and Hofmann’s violets – as well as newer coal-tar “azo” dyes like malachite green, London yellow and Congo Red – flooded the market, providing textile manufacturers and clothing designers with an even greater spectrum of fabrics and threads with which to ply their trade. The best technical account of the discovery and commercial

complained in 1885 that “the popular nomenclature of colors has of late years, especially since the introduction of aniline dyes and pigments, become involved in almost chaotic confusion through the coinage of a multitude of new names, many of them synonymous, and still more of them vague or variable in their meaning.”<sup>15</sup> He excoriated color names such as “Zulu,” “Crushed Strawberry,” and “Elephant’s Breath” as “nonsense” that was “invented at the caprice of the dyer” and unsuitable for any sort of “practical utility.” Pillsbury, likewise, blamed aniline dyes and trade color names for the general state of disarray in color nomenclature, and likewise singled out elephant’s breath and crushed strawberry for particular abuse, asking, “What more absurd terms could one easily choose to express an intelligible conception?”<sup>16</sup> Pillsbury and Ridgway’s frustration was not unfounded. Elephant’s breath – though not an aniline color – was identified in the popular magazine *Judy* in 1874 as “a very beautiful shade of blue with a sort of mistiness about it;” in *American Naturalist* in 1880 as “a pale olive-green hue;” in 1887 as a variation on

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development of aniline dyes is found in Anthony Travis, *The Rainbow Makers: the Origins of the Synthetic Dyestuffs Industry in Western Europe* (Bethlehem, London: Lehigh University Press, 1993). A more popular but no less informative account is Simon Garfield’s *Mauve: How one Man Invented a Color that Changed the World* (New York: Norton, 2001). Travis has also published numerous articles on particular aspects of the aniline dyes industries. See, for instance, Anthony Travis, “Perkin’s Mauve: Ancestor of the Organic Chemical Industry,” *Technology and Culture*, 31:1, Jan. 1990, pp. 51-82; Anthony Travis, “Science’s Powerful Companion: A. W. Hofmann’s Investigation of Aniline Red and Its Derivatives,” *The British Journal for the History of Science*, 25: 1, Mar. 1992, pp. 27-44; Anthony Travis, “From Manchester to Massachusetts via Mulhouse: The Transatlantic Voyage of Aniline Black,” *Technology and Culture*, 35:1, Jan. 1994, pp. 70-99; Anthony Travis, “Poisoned Groundwater and Contaminated Soil: The Tribulations and Trial of the First Major Manufacturer of Aniline Dyes,” *Environmental History*, 2:3, Jul. 1997, pp. 343-365. On some of the legal aspects of aniline dye production see Henk Van Den Belt, “Why Monopoly Failed: The Rise and Fall of Société La Fuchsine,” *The British Journal for the History of Science*, 25:1, Mar. 1992, pp. 45-63).

<sup>15</sup> Robert Ridgway, *A Nomenclature of Colors for Naturalists and Compendium of Useful Knowledge for Ornithologists* (Boston: Little, Brown, & Co., 1886) on pg. 26.

<sup>16</sup> J. H. Pillsbury, “A New Color Scheme,” *Science*, 19:473, 26 Feb. 1892, pg. 114.

lavender; in 1907 as a “Cool Purple Grey;” and in 1918 as a very grey variant of green.<sup>17</sup>

But the ability precisely to describe sensations was more than a matter of commercial or even scientific utility – it was a mark of cultural sophistication. Primitive people did not name colors as did the “civilized,” as Albert S. Gatschet, an ethnologist working for the United States Geological Survey, reported in his study of color terms in the Klamath, Dakota and Kalapua languages. For example, he wrote, the Modoc and Klamath Lake Indians of the Pacific Northwest (both of whom spoke varieties of Klamath) did not have a word color, and used only a few words to describe particular abstract color sensations. Instead, colors in Klamath tended to retain strong associations with particular objects – for example, Gatschet wrote that, “The Klamath language has two terms for green, one when applied to the color of the vegetals (kagd'kli), another when applied to garments and dress (tolalh'ptchi). Blue when said of beads is again another word than blue in flowers and blue in garments.”<sup>18</sup> Indeed, Gatschet recalled Klamath speakers “qualifying certain objects of nature by their color and then calling them by the same attribute, even when their color has been altered.” As an example of this phenomenon, Gatschet specified that “the name applied to the color of a quadruped may remain even when the animal has changed its color through the change of seasons.”<sup>19</sup>

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<sup>17</sup> Deb Salisbury, *Elephant's Breath and London Smoke* (Neustadt, Canada: Five Rivers Chapmanry, 2009) on pg. 75.

<sup>18</sup> Albert S. Gatschet, “Adjectives of Color in Indian Languages,” *The American Naturalist*, 13:8, Aug. 1879, pp. 475-485, on pg. 483.

<sup>19</sup> *Ibid.* on pg. 484.

The ways that people used color terms, and the vocabularies available to them, moreover, indicated both individual mental ability as well as the sophistication of their culture. R.S. Woodworth, a psychologist at Columbia College who had studied the color perception of Filipinos at the 1904 St. Louis Exposition, wrote that the question was not whether “uncivilized” people *saw* differently from civilized, but rather “[w]hy should color nomenclature [of some languages] not be fairly adequate to the development of the color sense” – which Woodworth felt not to vary much across “normal eyes” observers in all cultures – “and why should it be so much further advanced among some peoples than others?”<sup>20</sup> The answer appeared to Woodworth almost banal. “We may fairly assume, with Wundt,” he wrote, “that abstract color names are of relatively late introduction into any language, and that they are developed out of names for colored objects; so that the question is primarily regarding [the] hardening and dissociation of linguistic usage”<sup>21</sup> Colors tended to be abstracted in languages, Woodworth continued, in direct relation to their utility to speakers, as determined by the advancement of their culture. “Red” – as the color of blood and ripe fruit – was an obvious candidate for early abstraction, as was yellow, a color/word that was used in conjunction with red, Woodworth speculated, for distinguishing the cattle upon which early agricultural civilizations depended for trade and subsistence. Blues and greens, meanwhile, tended not to be so necessary for “primitive” people, since blue and green were colors principally of the sky and of leaves – not items with particular

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<sup>20</sup> R.S. Woodworth, “The Puzzle of Color Vocabularies,” *the Psychological Bulletin*, VII:10, 15 Oct. 1910, pp. 326-333, on pg. 332-333.

<sup>21</sup> *Ibid.*



utility for primitive people, and which therefore could be adequately described simply with nouns referring to the objects (this leaf, that sky, etc). It was only "[w]ith the introduction of green and blue paints and dyes," Woodworth concluded, that "these colors become important marks in distinguishing household objects; and it is probably owing to the use of pigments that names for green and blue have become stereotyped in European languages"<sup>22</sup> British psychologist Grant Allen came to a similar conclusion, arguing in *The Colour-Sense: its Origin and Development* (1895) that abstract words for color could only be the result of mental and cultural sophistication. "An educated man," wrote Allen, "if asked to describe a grape would answer, 'It's a small, round, sweet, purple, fruit which grows in clusters on a twining vine;' but a labourer would have recourse to better known concrete objects and reply, 'It's something like a plum, only about the size of a cherry, and grows in bunches the same as currants.'"<sup>23</sup> Indeed, Allen pointed out, the same thing was true in the naming of natural objects – "if a naturalist discovers for the first time a new animal – say an argus pheasant – he will minutely characterize its shape, size, colour, external appearance, and internal structure, detailing all these points in extremely abstract language; whereas a countryman who goes to the Zoological Gardens will simply describe it as 'between a peacock and a guinea-hen.'"<sup>24</sup> Allen's point was that faculty with color spoke to a deeply ingrained mental dexterity. However, exactly *how* even the most sophisticated naturalist ought to go about

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<sup>22</sup> *Ibid.* on pg. 334.

<sup>23</sup> Grant Allen, *The Colour-Sense: Its Origin and Development* (London: Kegan Paul, Trench, Trübner, & Co Ltd, 1892) on pg. 250-251.

<sup>24</sup> *Ibid.* on pg. 251.

minutely characterizing the color of a new bird was the problem that plagued semantically exacting naturalists such as Ridgway.

It was the sort of hierarchical relationship described by Woodworth and Allen – with advanced civilizations deploying more accurate, more sophisticated, more abstract color terms than their primitive juniors – that lay at the root of discussions of color terms in the nineteenth century. This is what Ladd-Franklin found so amazing about Eskimo color terms – not that their color language betrayed a color sense on par with those of “civilized people” (which, in essence, was the lesson that Rivers took away from his study) – but rather that the primitive Eskimos seemed to have a better-realized sense than their civilized brethren of the relationship between color and words. Lacking a sophisticated system of commercial exchange or complicated technologies – or even “science” – they were nevertheless able to speak about colors with “scientific” accuracy. Likewise, Milton Bradley suggested a similar, if more antagonistic, juxtaposition between the color terms used by primitive cultures and those of “advanced” cultures when he warned that, “those semi-civilized nations whose drawings are the least artistic greatly surpass us in natural color perceptions.” This gap in perceptual acuity, thought Bradley, was a result of the confused color vocabulary of modern humankind. “[A]s!” he exclaimed, “the paintings of the old masters [of Europe] have faded and the great dyer [i.e. Chevrue] had no language in which to describe his color in his writings, and therefore it is claimed that little or no advance in color perception has been made in modern times, if indeed we have held our own”<sup>25</sup> While Ladd-Franklin

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<sup>25</sup> Milton Bradley, *Elementary Color* (Springfield: Milton Bradley Co., 1895) on pg. 6.

voiced her interest in Eskimo color names as a developmental curiosity, Bradley saw the problem as one of developmental competition: civilized people needed to define their color vocabularies or lose ground to the “semi-civilized.” But both saw the precise definition of color terms as a necessary part of any “advanced” civilization based on science.

This variety of hierarchical thinking about color sensation, language, and cultural sophistication, moreover, has persisted in the late twentieth and into the twenty-first. Perhaps its most influential descendant can be found in the color studies of Brent Berlin and Paul Kay, whose *Basic Color Terms* (1969) posited a sequential development of words for colors in all languages: any language first develops terms for black and white, then adds red, then blue or green, then blue *and* green, and so forth until reaching the maximum compliment of eleven basic color terms – black, white, red, yellow, blue, green, brown, purple, pink, orange, and gray – exhibited by European (and some Asian) civilizations.<sup>26</sup> For Berlin and Kay, this sequence of the development of color words in languages is universal – part of the biological makeup of human beings – and while the authors demure from speculating on the precise neurological basis of the basic color terms, they do indicate a “positive correlation between general cultural complexity (and/or level of development) and complexity of color vocabulary.”<sup>27</sup> Indeed, with echoes of Woodworth, the authors write that the “elaboration of a color lexicon is an evolutionary one accompanying, and perhaps a reflex of, increasing technological

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<sup>26</sup> For an explanation of methodology and assumptions, see Brent Berlin and Paul Kay, *Basic Color Terms* (Stanford, Calif.: Center for the Study of Language and Information, 1999:1969) on pp. 1-45.

<sup>27</sup> *Ibid.* on pg. 16.

and cultural advancement” – for example, “to a group whose members have frequent occasion to contrast fine shades of leaf color and who possess no dyed fabrics, color-coded electrical wires, and so forth, it may not be worthwhile to rote-learn labels for gross perceptual discriminations such as green/blue, despite the psychological salience of such contrasts.”<sup>28</sup>

It is precisely the “elaboration of a color lexicon” that is the topic of this chapter. But whereas Berlin and Kay take for granted the notion that “psychological salience” can inhere in the sensory apparatus of human beings as expressed through language, Ridgway, Pillsbury, Bradley, and Ladd-Franklin struggled to define what, precisely, the basis of color language was, what it ought to be, and how color terms ought to work. For these individuals, color terms did, of course, have a utility, but they also had a social and even moral dimension. The project to define specific color terms was both a project about what color terms ought to be, and how human being ought to speak, see, and think of themselves in a modern technological society.

### The Ornithologist

Among the earliest comprehensive attempts at systematic color notation in America was Robert Ridgeway’s 1886 manual, *A Nomenclature of Colors for Naturalists and Compendium of Useful Knowledge for Ornithologists*. Part field manual, part introductory textbook, and part mission statement, *A Nomenclature of Colors for Naturalists* was intended, as Ridgeway put it, “to supply a want much felt by the author during the course of his ornithological studies [...]; namely a nomenclature of colors and a compendious dictionary of technical terms used in descriptive

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<sup>28</sup> *Ibid.*

ornithology.”<sup>29</sup> To accomplish these ends, Ridgeway stuffed his book with useful material: in its 200 pages, readers found diagrams of avian morphology; tables of feather types; illustrations of different egg shapes; a fifty-page glossary of ornithological terms; and even a printed ruler scored in French inches, English inches, and millimeters, along with several pages of handy conversion charts between the different types of measurements. The book also included color tables – pages and pages of rows upon rows of neatly painted squares of pigment, each painstakingly categorized, arranged, and named.

A prominent ornithologist, Ridgeway’s interest in color and naming – as well as birds – took root during a childhood in Mount Carmel, Illinois. The oldest child of “nature loving” parents, Ridgeway spent long hours in the forests around his house, where his father would point out the different species of avian fauna and identify them, often with made-up names: “the Towhee he called ‘Ground Robin,’” remembered Ridgeway, “the Wood Thrush was his ‘Bell Bird’; Gnatcatcher, ‘Blue Wren’; Yellow-breasted Chat, ‘Yellow Mockingbird’; etc.”<sup>30</sup> As Ridgeway grew older, his avidly collected these birds, though, one of his many correspondents recalled, the enthusiastic amateur naturalist had “no idea how to preserve a bird other than in a colored drawing” – a situation which sent Ridgeway to his father’s pharmacy to mix his own watercolors.<sup>31</sup> In 1864, having sent one of his collection drawings to Washington, D.C. in an attempt to identify an unknown bird, Ridgeway struck up a correspondence with the Smithsonian Institution’s Assistant Secretary, Spencer

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<sup>29</sup> Ridgeway, *A Nomenclature of Colors for Naturalists*, on pg. 9.

<sup>30</sup> Harry Harris, “Robert Ridgeway,” *The Condor*, XXX:1, Jan-Feb. 1928, pp. 5-118, on pg. 9.

<sup>31</sup> *Ibid.* on pg. 12.

Baird, who identified Ridgway's mystery bird as a purple finch.<sup>32</sup> Three years later, Baird hired Ridgway as a field zoologist, and Ridgway spent the rest of his life observing birds for the Smithsonian. By the time he was named the Smithsonian's first director of ornithology, in 1880, Ridgway had overcome many of his boyhood obstacles – he was skilled at speaking about birds with scientific precision, and had learned how to preserve his specimens through taxidermy rather than watercolors – but questions of how precisely to denote the colors of the birds that he observed still preoccupied him.<sup>33</sup>

In one way, then, Ridgway's *Nomenclature* can be seen as a gift to his boyhood self – a self-help manual for the aspiring ornithologist. But its key claim to scientific novelty was its treatment of colors. Naturalists, explained Ridgway, “demand a nomenclature which shall fix a standard for the numerous hues, tints, and shades which [...] now form part of the language of descriptive natural history” – and Ridgway's book was an attempt to deliver.<sup>34</sup> True, Ridgway continued, other authors had written about color – and he dutifully listed von Bezold and Rood among many others in his bibliography – but these books seemed to dismiss the exact nature of the relationship between color sensations and the words used to describe them as a matter beneath the scope of scientific inquiry. Ridgway complained, for instance, that von Bezold dodged the question of color terms, writing in his *Theory of Colour in its Relation to Art and Industry* that “the names of colors, as usually employed, have so little to do with the scientific or technical

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<sup>32</sup> Alexander Wetmore, “Biographical Memoir of Robert Ridgway,” *National Academy of Sciences, Biographical Memoirs*, Vol. XV, 1931, on pg. 59.

<sup>33</sup> Harris, “Robert Ridgway,” on pg. 13.

<sup>34</sup> Ridgway, *A Nomenclature of Colors for Naturalists*, on pg. 15.

aspects of the subject that we are in reality dealing with the peculiarities of language.”<sup>35</sup> For Ridgeway, though, it was precisely those “peculiarities of language” that demanded a “scientific and technical” intervention. Physicists and physiologists had ably explained the *causes* of color sensations, but had neglected to imbue them with any meaning. Ridgeway’s goal was simply to provide a scientifically accurate but colloquially usable means by which naturalists and laypeople could identify the sensations that they experienced and convey them to other people.

How precisely, this was to be done, however, was unclear, and Ridgeway attempted to organize and explain his color nomenclature around a number of scientifically inspired, but inconsistently applied conceits. For example, in order to begin systematically naming colors, Ridgeway first attempted to categorize them, following von Bezold by dividing all colors into two categories: “Pure colors of the solar spectrum,” and “Impure colors, or those not found in the solar spectrum.”<sup>36</sup> Red, for instance, would count as a pure color, while brown would be classed among the impure (it is not totally clear whether Ridgeway thought of white and black as colors per se, though he implied that they were absolute degrees of impure colors – i.e. maximally shaded or maximally lightened colors inevitably ended up as white or

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<sup>35</sup> *Ibid.* Von Bezold had, in fact, acknowledged the problem of indefinite naming in the English translation of his work, urging readers to “pay special attention to those passages in which it has been attempted to define with scientific accuracy the somewhat loose terms in common use” (Wilhelm von Bezold, *Theory of Color in its Relation to Art and Industry*, S.R. Koehler, Trans, Boston: Prang, 1876, on pg. vi ). But readers desiring such definitions (i.e. like Ridgeway) could only have been disappointed to learn that, in cases of fine discrimination such as between lilac and purple, “we are in reality only dealing with peculiarities of language” – that is, precisely the problem that von Bezold’s commitment to “scientific accuracy” was supposed to clear up (von Bezold, *Theory of Color*, on pg. 99). In any case, while Ridgeway did not accurately quote von Bezold, his argument still has substance.

<sup>36</sup> *Ibid.* on pg. 20.

black. In this, it should be noted, he rejected von Bezold's suggestion that white and black belonged in a separate category of colors along with "gold" and "silver," since Ridgeway felt that gold and silver were, properly speaking, variants of yellow and white, respectively). The "pure" colors in turn could be divided into two tiers. Primary colors – "those not produced by mixture" – consisted of "red," "yellow," and "blue;" secondary colors were "those produced by the mixture of two primary colors" which Ridgeway notated as "orange (=red+yellow)," "Green (=yellow+blue)" and "Purple (=blue+red)." This same additive principle could be applied to the "impure colors," which Ridgeway divided into three classes– "shades," "tints," and "subdued colors" – all of which were some combination of primary or secondary colors and white or black. Thus Ridgeway considered "olive" to be a shade of yellow, and notated it as "yellow+black."<sup>37</sup> By arranging his "pure" colors in an eighteen-fold "spectrum series" – i.e. a cycle of colors from red to purple divided into eighteen parts – and thinking of impure colors as additions of white or black to this series, Ridgeway could, in principle, sort all of his colors into distinct sets of like and unlike colors, allowing even ostensibly unmoored colors like "elephants breath" to find a berth in a stable system of nomenclature.

Realizing his system on the printed page, however, proved a good deal more problematic than theorizing the order of natural color. To explain his method for *producing* his swatches of color, Ridgeway abandoned his categorization system without explanation, and started again, this time noting that pigments and light mixed quite differently. Thus, even though he acknowledged that one of his primary

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<sup>37</sup> *Ibid.* on pg. 21.



colors ought to be *green*, and not yellow – at least according to psychophysical studies such as those of Rood and von Bezold – he was forced to reinstate yellow as a primary color, since certain yellow and blue pigments could combine to make a passable green on the printed page, but no known combinations of red and green pigment would make a viable yellow. Having cast his lot with the practicalities of printing rather than the ideal world of the psychophysical laboratory, he dismissed the eighteen-fold spectral divisions that he had explained at length in the opening pages of his treatise, and began to assemble his color reference samples on the basis of thirty six commercially available watercolors – half of which, Ridgeway explained, were selected from his personal collection of three hundred quality watercolors “for convenience, rather than because they are necessary.”<sup>38</sup> Commercial colors of the same name, in turn, often varied considerably from maker to maker; the “Olive Green” of Winsor & Newton was not the same color as the “Olive Green” of Schoenfeld’s, in spite of their homonymous designations. The given name of a paint product did not necessarily stand for the sensation engendered by the paint.

Having explained his system both in terms of the logical order of colors and the practicalities of working in watercolors, Ridgeway then compiled tables of color samples mixed from different combinations of his thirty-six hues. He arranged his samples according to a rough sense of dominant spectral color – greens classed with greens, reds classed with reds, and so forth – although, as Ridgeway admitted, “in not a few cases it has been a difficult matter to decide upon which plate a certain [color] should be put, the decision being in some instances almost purely

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<sup>38</sup> *Ibid.* on pg. 27.

arbitrary.”<sup>39</sup> Each plate contained up to twenty-one rectangles of color, some still bearing the brushstrokes of paint application, arrayed in neat grids (figure 4.1). The rectangles were numbered and labeled, and keyed to recipes for the specific color cited. For instance, on plate VII, which appears to be devoted to orangey-red colors, item number 17, “Salmon Color,” could be recreated with a combination of “scarlet vermilion +cadmium orange+white.” Item number 9, “Poppy Red,” was equivalent simply to “Burgeois’s “laque ponceau.””<sup>40</sup> Ridgeway didn’t give proportions of the particular colors to be used, but he did note, helpfully, that his was not a transitive addition: “red + black,” he remarked, “and ‘black + red’ imply very different relative proportions of the two colors; the former being *black* modified by admixture of a small quantity of red, the latter being *red* modified by the addition of a little black.”<sup>41</sup> Specifically, “black + red” were the constituent parts of “seal brown;” while “red+black” equaled a “burnt carmine.”

In one sense, Ridgeway’s distribution of his different color chips into their given plates was reminiscent of Holmgren’s color blindness tests. Instead of skeins of yarn to be sorted into bundles of like color, the task Ridgeway assigned himself was sorting colored rectangles of paper into tables of similar color. Unlike in Holmgren’s color-blindness test, however, naming the colors was not only permitted, but imperative – the whole point of his book was to name each and every color precisely as it was placed in its logical relation to the other colors. This – more than the natural arrangement of colors, or the logic of pigment mixing – was at the

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<sup>39</sup> *Ibid.* on pg. 26.

<sup>40</sup> *Ibid.* on pg. 34.

<sup>41</sup> *Ibid.* on pg. 36.

heart of Ridgway's enterprise, and he took the matter of naming seriously. Indeed, it preoccupied him enough so that he prefaced his color tables with a lengthy apologia explaining his misgivings in attempting to name all of the colors that he presented.

Ridgway's concerns about color names boiled down to the nature of the relationship between object and percept; words and things. As Ridgway explained:

The selection of appropriate names for the colors depicted on the plates has been in some cases a matter of considerable difficulty. With regard to certain ones it may appear that the names adopted are not entirely satisfactory; but to forestall such criticism, it may be explained that the purpose of these plates is *not to show the color of the particular objects or substances which the names suggest, but to provide for the colors which it has seemed desirable to represent, appropriate or at least approximately appropriate names*. In other words, certain colors are selected for illustration, for which names must be provided; and when names that are exclusively pertinent or otherwise entirely satisfactory are not at hand, they must be looked up or invented. It should also be borne in mind that almost any object or substance varies more or less in color; and that therefore if the "orange," "lemon" or "chestnut" of the plates does not match exactly in color the particular orange, lemon or chestnut which one may compare it with, it may (or in fact does) correspond with other specimens. It is, in fact, only in the case of those colors which derive their names directly from pigments which represent them (as Paris

green, orange-cadmium, vermilion, ultramarine blue, madder-brown, etc.)

that we have absolute pertinence of names to color.<sup>42</sup>

Far from “forestalling criticism,” however, Ridgway’s explanation for his naming rationale raises only questions about what sorts of practical and epistemological duties Ridgway felt to be included in the work of naming colors. For one thing, if Ridgway felt himself vulnerable on account of the “not entirely satisfactory” names that he chose for his colors, then what would constitute “satisfactory” names? What did names *do* and what were the necessary and sufficient conditions for a sign to properly match with its referent? For another thing, what did Ridgway understand the nature of his color naming exercise to be? If the purpose of his colored plates was “*not to show the color of the particular objects or substances,*” then what did it matter if the sample of color on plate XIV labeled “lemon yellow” matched all lemons, some lemons, one particular lemon, or no lemons at all? (For that matter, how frequently did one encounter a stalk of broccoli that matched Ridgway’s “Broccoli Brown”?). What were the brilliantly colored rectangles in his book representative of, anyway? Everyday objects? Chemicals? Birds? Sensations? Ideas?

In working through these questions, Ridgway looked to scientific precedent, and found a particularly compelling one in *Werner’s Notation of Color*, a mineralogical text originally published in 1814. Perhaps appropriately for a volume dealing with the ambiguities of naming, *Werner’s Notation* was not, in fact, authored by the eponymous Werner, but by Patrick Syme – a Scottish flower illustrator and

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<sup>42</sup> *Ibid.* on pg. 16.

“painter to the Wernerian and Horticultural Societies.”<sup>43</sup> Syme took the name and the basic material for his color nomenclature from the work of Prussian mineralogist Abraham Gottlob Werner, who had compiled eight “suites” of seventy-six color samples to assist his fellow “orycognosts” identifying the broad variety of colors characteristic of certain minerals.<sup>44</sup> The “green” suite, for instance, featured all those shades of green that Werner felt through examination of his own sensations to lie between yellow and blue, arranged by degrees from the yellowiest (“siskin green”) through the bluest (“verdigris green”) with “emerald green” occupying the middle position – thus allowing a mineralogist faced with an unknown green stone to, in theory, express a wide range of chromatic sensations.<sup>45</sup>

Syme faithfully reproduced Werner’s system in his own text, while ironing out certain idiosyncrasies. For example, Werner had neglected to include purple and orange among his eight principle colors, instead classing their members within the “blue” and “yellow” suites – a decision that Syme overrode, noting that orange and purple “are as much entitled to the name of colours as green, grey, brown or any other composition colour.”<sup>46</sup> Likewise, Syme felt compelled to add thirty-four colors to Werner’s original seventy-six, while rearranging the placement of some colors in Werner’s scheme and renaming others. In doing so, Syme felt he had usefully

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<sup>43</sup> Robert Jameson, *A Treatise on the External, Chemical, and Physical Characters of Minerals* (Edinburg: Neill & Company, 1816) on pg. 86.

<sup>44</sup> Robert Jameson described Werner’s system in depth in *A Treatise on the External, Chemical, and Physical Characters of Minerals*, pp. 55 – 89; on Werner’s classification of minerals more generally – including his use of color suites in classifying minerals – see Thomas Thomson, “Some Observations in Answer to Mr. Chenevix’s Attack upon Werner’s Mineralogical Method,” *Annals of Philosophy*, 1:4, April 1813, pp. 241-258.

<sup>45</sup> Jameson, *A Treatise on the External, Chemical, and Physical Characters of Minerals*, on pg. 59

<sup>46</sup> Patrick Syme, *Werner’s Nomenclature of Colours, with Additions, Arranged so as to Render it Highly Useful to the Arts and Sciences. Annexed to Which are Examples Selected from Well-known Objects in the Animal, Vegetable, and Mineral Kingdoms* (Edinburgh, W. Blackwood, 1814) on pg. 7.

expanded Werner's system, assuring readers that his was more than just a book for mineralogists, or indeed men of science. As Syme explained, it was his intention to "remove the present confusion in the names of colours, and establish a standard that may be useful in general science" – if not, indeed, "as a general standard to refer to in the description of any object."<sup>47</sup>

For both Syme and Werner, colors were functions of things, and their conventions for naming and displaying colors reflected this relationship, albeit idiosyncratically. In his explanation of Werner's color tables, Robert Jameson, a Scottish mineralogist and one of Werner's translators, explained that "[t]he names of the colours are derived, 1st, From certain bodies in which they most commonly occur, as milk-white, siskin-green, liver-brown; 2d, From metallic substances, as silver-white, iron-black, and yellow-gold; 3d, From names used by painters, as indigo blue, verdigris-green, and azure-blue; 4th, From that colour in the composition which is next in quantity to the principal colour, as bluish-grey, yellowish-brown, &c.; and 5th, From the names of persons, as Isabella-yellow, now called cream yellow."<sup>48</sup> For his part, Syme, borrowing many of Werner's names, declined to specify his naming convention, but instead listed examples of each color as it appeared in the animal, vegetable, and mineral kingdoms. Although in many instances, Syme's names conformed to Werner's first rule that color names indicated characteristically colored objects, Syme's pairings of names and objects could prove idiosyncratic. For instance, the color that Syme called "plum purple" was, reasonably enough, closely identified with plums; "straw yellow," for its part,

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<sup>47</sup> *Ibid.* on pg. 3 and on pg. 1.

<sup>48</sup> Jameson, *A Treatise on the External, Chemical, and Physical Characters of Minerals*, on pg. 59.

was the color of “oat straw.” “Asparagus green,” however, was not best found in asparagus plants, but rather in the “variegated horse-shoe geranium,” while “lemon yellow” was, inexplicably, exemplified not by lemons, but by “shrubby goldylocks.”<sup>49</sup> Syme’s pairings of names and objects could veer from the fanciful to the disturbingly specific: “oil green,” was to be found on “a nonpareil apple from the wall;” “Prussian blue” was exemplified by the “beauty spot on [the] wing of [a] mallard drake;” while the best exemplar of “bluish black” among members of the animal kingdom was the “largest black slug.”<sup>50</sup> Both Syme and Werner, then, labored to make associations between specific colors and specific objects, though not consistently through names that linked the two.

Building upon the precedent set by Werner and dramatized through Syme, Ridgway preserved the strong association between the things that color terms named, and the color sensations that they described. For Ridgeway, colors were necessarily products or effects of things in the world; their names, therefore, ideally referenced those things – even if the things were chemicals, or familiar objects. Rather than attaching names to sensations, Ridgway’s color nomenclature was, in a sense, a shortcut to matching colored object to colored object. That is, by designating a bird (or part of a bird) as, for instance, “lemon yellow” according to Ridgway’s system, one was necessarily making an association not between the bird and an abstract concept of a particular variety of yellow, but rather between a particular bird and a particular yellow lemon. In essence, by his own understanding

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<sup>49</sup> Syme, *Werner’s Nomenclature of Colours*, on pg. 48.

<sup>50</sup> *Ibid.* on pg. 23.

of the weight that his color names bore, Ridgway's book was a shortcut to saying, "this bird is the same color as *that* lemon," rather than "this bird is lemon yellow."

Indeed, in his own ornithological practice, Ridgway maintained this equation between things in the world as colored objects, rather than the colors of things in the world abstracted into color chips. For example, in describing "A Singularly marked Specimen of *Sphyrapicus Thyroideus*" Ridgway referred to a species of Williamson's sapsucker (a type of woodpecker) as being unusual for the "crimson-scarlet" marking upon its head – even though crimson-scarlet is not a color notated in *A Nomenclature of Colors*. This "red crown-patch" he continued, was similar in color to the cap adorning the Gila woodpecker, but was "more scarlet" in the case of the sapsucker; moreover the belly of the "unusual specimen," was "rather pale" for Californian examples of this species – interesting distinctions, but ones which would have little meaning to an individual who lacked a strong sense of the coloration of Gila woodpeckers and Williamson's sapsuckers, even if they were equipped with a copy of Ridgway's nomenclature.<sup>51</sup> Similarly, when attempting to describe "two Abnormally Colored Specimens of the Bluebird," Ridgway mingled ostensible exactitude of his system with vernacular ambiguity. Although he could describe the typical coloration of a bluebird's throat plumage as "cinnamon colored" (corresponding to box number 20 on plate III of his *color notation*), for the more unusual colors Ridgway could only say that they were a "very rich uniform azure blue, almost precisely the same shade as in *S. arctica*, but even rather more greenish

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<sup>51</sup> Robert Ridgway, "A Singularly Marked Specimen of *Sphyrapicus Thyroideus*," *The Auk*, 4:1, Jan. 1887, pp. 75-76.



than in many examples of the latter species.”<sup>52</sup> Again, as with the sapsuckers, Ridgway’s descriptions do little to precisely name the unusual hues of the animals he’s describing, at least according to his own color charts. Instead of finding the unusual colors of the birds on his color charts (perhaps among the greener shades of blue) he can do little better than to point his reader to “azure blue” (plate IX, box 15), then quickly redirect his reader to a “greenish” version of an azure blue bird, in this case, *S. arctica*, or the arctic bluebird.

Other naturalists appear to have been more rigorous in their use of Ridgway’s color nomenclature. Amateur birder Frank L. Burns, in a monograph on flickers – another type of woodpecker – employed Ridgway’s terminology with a gusto, writing that, among adult male flickers,

“[t]he scapulars, wing-coverts and exposed secondaries are [...] often as light as broccoli-brown; the bars vary only in width. The top of the head is occasionally washed with umber or tawny, and the nuchal crescent varies greatly in extent and in color from scarlet to vermilion. The sides of head, chin, throat and forebreast [vary] from drab through fawn, ecru-drab to vinaceous-cinnamon.”

Immature females of the flicker, he continued, had much the same color as the males, but

“the feathers of the forehead and crown are usually tipped or mottled with scarlet vermilion, dragon’s blood or brick-red, posteriorly fading to a rusty

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<sup>52</sup> Robert Ridgway, “On Two Abnormally Colored Specimens of the Bluebird (*Sialia sialis*),” *The Auk*, 3:2 Apr. 1886, pp. 282-283, on pg. 282.

brown or burnt umber over the ashy-grey, which extends almost around the eye in some specimens.”<sup>53</sup>

Similarly, naturalist Gerrit S. Miller, an assistant curator of mammals at the Smithsonian’s United States National Museum, identified the markings of two Scarlet Tanager specimens as “gamboge-yellow” – a common paint hue, as well as one of Ridgway’s colors – and elsewhere he described the markings of the “adult female” great lizard cuckoo as “[h]air-brown on the back and head, fading to broccoli-brown on the neck, the feathers everywhere glossed with sage green.”<sup>54</sup> Indeed, Miller found use for Ridgway’s color names in his work with mammals as well as birds: a new species of rabbit was “a fine grizzle of reddish brown,” which Miller qualified as “intermediate between the wood brown and russet of Ridgway;”<sup>55</sup> while a species of bat (*Chilonycteris Mexicana*) found in San Blas, Tepic, Mexico, had a back of “uniform brown, most closely resembling the broccoli-brown

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<sup>53</sup> Frank L. Burns, “A Monograph of the Flicker. (*Colaptes auratus*),” *The Wilson Bulletin*, 12:2, Apr. 1900, pp. 1-83, on pp. 70-71. Interestingly, Burns devoted a portion of his monograph to speculation about the different common names of the flicker – naming conventions that he described as “Descriptive, Onomato-poetic, [and] Misnomers” (5). Descriptive names captured something about the creature’s manner or bearing – for example, among residents of Cape Cod the bird was known as the “fiddler,” possibly on account of “the peculiar sew-saw motions indulged in by the males while courting the females during the early spring months.” (6). Onomatopoeic terms were imitations of the bird’s calls – such as “claype,” as the bird was known in Western New York (5). Misnomers were simply misidentifications of the flicker with other birds’ names, e.g. “golden winged woodcock,” which the flicker was not, except when observed by some of the less discerning residents of Iowa (7). The term “flicker” itself Burns noted, might either be descriptive of the “the peculiar twinkling or flickering of the bright shafts when the wings open and close in flight;” or else onomatopoeic, deriving from the “wicher” sound of the bird’s song (6). In general, Burns was opposed to naming creatures after their putative human discoverers, finding “the servitude of the prefixed personal name” to be inferior to “[n]ames descriptive of form, flight, plumage, notes, habits, habitat, characteristics, etc., or of onomatopoeic origin,” as long as the latter were “short and catchy” – as apt a summary of the problems of naming as any in the color literature (4).

<sup>54</sup> Gerrit S. Miller, Jr., “Some Abnormal Color Markings,” *The Auk*, 14:3, Jul. 1897, pp. 275-278, on pg. 277; Gerrit S. Miller, Jr., “The Ground Cuckoo of Andros Island,” *The Auk*, 11:2, Apr. 1894, pp. 164-165, on pg. 164.

<sup>55</sup>Gerrit S. Miller, Jr., “Descriptions of Six New American Rabbits,” *Proceedings of the Academy of Natural Sciences of Philadelphia*, 51:2, Apr. - Sept. 1899, pp. 380-390, on pg. 383, and n.6.

of Ridgway, “but darker and with a mixture of both hair-brown and drab [with] [u]nder parts wood-brown, much lighter than Ridgway’s Plate III, fig. 19, the hairs distinctly dark slaty-brown at base.”<sup>56</sup> Burns and Miller were only some of the earlier adopters of Ridgway’s nomenclature. By the turn of the century, Ridgway’s color names found use among mammalogists, entomologists, and mycologists as well as his core constituency of ornithologists.<sup>57</sup>

Beyond its use by some zoologists and botanists, however, it wasn’t clear how viable Ridgway’s system was. On the one hand, a reviewer for the *American Naturalist* was very enthusiastic, writing, “[c]ould this nomenclature have a further introduction, and its terminology replace the meaningless terms like ‘elephant’s breath’ etc. introduced into trade, it would have a very beneficial effect.”<sup>58</sup> Others, however, had their doubts. While generally lauding Ridgway’s efforts, Joel Asaph Allen, who Ridgway had some years earlier recommended for a position as ornithologist of the American Museum of Natural History, was somewhat more measured in his appraisal, giving credit to Ridgway for taking on a “difficult task requiring [...] skill as a colorist, combined with critical knowledge of the requirements of descriptive ornithology,” but concluding that the color section of

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<sup>56</sup> Gerrit S. Miller, Jr., “Twenty New American Bats,” *Proceedings of the Academy of Natural Sciences of Philadelphia*, 54:2 (May - Sept., 1902), pp. 389-412 on pg. 402.

<sup>57</sup> After Miller’s work with bats, Portland, Oregon’s Samuel N. Rhodes was an early adopter of Ridgway’s nomenclature for use in describing mammals; see Samuel N. Rhoads, “Contributions to a Revision of the North American Beavers, Otters and Fishers,” *Transactions of the American Philosophical Society*, 19:3, 1898, pp. 417-439. For an early example of Ridgway’s system in use in entomology – particularly as used to describe butterflies – see, e.g. James A. G. Rehn, “A Contribution to the Knowledge of the Acrididæ (Orthoptera) of Costa Rica,” *Proceedings of the Academy of Natural Sciences of Philadelphia*, Vol. 57, 1905, pp. 400-454; and other articles from the period by Rehn. For an early example of Ridgway’s use in mycology see Charles H. Peck, “New Species of Fungi,” *Bulletin of the Torrey Botanical Club*, 22:5, 15 May 1895, pp. 198-211. Ridgway was, nevertheless, still most popular among ornithologists.

<sup>58</sup> “Ridgway’s Nomenclature of Colors,” *American Naturalist*, 21:2, February, 1887, pp. 166-167, on pp. 166-167.

the book “fails by far, from the nature of the subject, to clear away all the difficulties, since the names of colors in current use are in many cases both vague and variable.”<sup>59</sup> Ridgway’s “broccoli brown” and “Terre verte Green,” that is, did little to clear up either the vagueness or the variability of his color nomenclature. W. Hallock and R. Gordon, writers for the new *Standard Dictionary*, were more pointed, lampooning Ridgway’s system (though not by name) as one that endeavored “to take an orange as a type of that color, and in like manner to let a lemon, an olive, etc. be the ultimate definition of those hues.”<sup>60</sup> Such a system would inevitably come up short as a scientific nomenclature, concluded Hallock and Gordon, since any properly scientific system of color terminology had to do more than simply define the color of an object’s surface “by saying that it resembles or differs to a certain extent from some other arbitrary surface.”<sup>61</sup>

In 1909, Ridgway himself denounced his 1885 edition as “manifestly seriously defective in the inadequate number of colors represented, their unscientific arrangement, and the bad method of their reproduction” and revealed that he had been working for years on a revised edition to his system.<sup>62</sup> In 1912, he released a volume devoted exclusively to color names entitled *Color Standards and Color Nomenclature*.<sup>63</sup> As with its predecessor, *Color Standards* was written so that all “who may have occasion to write or speak of colors may do so with the certainty that there need be no question as to what particular tint, shade, or degree of

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<sup>59</sup> J.A. Allen, “Review: Ridgway’s Nomenclature of Colors and Ornithologists’ Compendium,” *the Auk*, 4:2, April 1887, pp. 152-153, on pg. 153.

<sup>60</sup> W. Hallock and R. Gordon, “Color Standards,” *Science*, 6:136, Aug. 6, 1897, pp. 214-215, on pg. 214

<sup>61</sup> *Ibid.*

<sup>62</sup> Robert Ridgway and H. B. Kaeding, “Correspondence,” *The Condor*, 11:6, Nov. - Dec. 1909, pp. 210-211.

<sup>63</sup> Robert Ridgway, *Color Standards and Color Nomenclature*, Washington, D.C.: The Author, 1912.

grayness, of any color or hue is meant.”<sup>64</sup> But unlike his 1885 edition, Ridgway revisited color science in earnest, struggling to arrange his new colors – which numbered over 1,000 – according to the standards of contemporary psychophysics. The cover of his book bore the imprint of a Maxwell disk with red, green, and violet sections to symbolize his attentiveness to scientific understandings of color; and, he wrote, he had spent the past twenty years compiling an exhaustive collection of “several thousand samples of named colors” that he found in commercial color books, painters’ pigments, and manufactured items.<sup>65</sup> In so doing, Ridgway explained, he hoped to “standardize colors and color names, by elimination of the element of “personal equation” – that is, the subjective disagreement between observers as to what, precisely, color terms meant. Nevertheless, Ridgway still struggled with the nature of the color names he used, reprinting almost in its entirety his apologia from 1886 in the new edition (while expanding his musings on ideal lemons and chestnuts to include oranges and lilacs.) He helpfully listed his thousand new color terms in alphabetical order in the front of the book – and yet, for all of his extensive collecting, Ridgway was no closer to a settled understanding of what those terms meant.

### The Pastor and the Printer

In producing his second edition, Ridgway pronounced himself indebted to the work of an unlikely pair of collaborators, the botanist and Methodist minister, John Henry Pillsbury, and the board game tycoon and elementary school reformer, Milton

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<sup>64</sup> *Ibid.* on pg. 1.

<sup>65</sup> *Ibid.* on pg. 11.

Bradley. “The scientific arrangement of colors in this work,” Ridgway explained, “is based essentially on the suggestions of Professor J.H. Pillsbury for a scheme of color standards,” while Ridgway claimed to have “learned more, and learned it more easily,” from Bradley’s 1895 text, *Elementary Color*, “than from careful study of more elaborate and authoritative works on the subject.”<sup>66</sup> Ridgway quoted Bradley’s complaints on the imprecise nature of modifying terms for color as one of the motivating sources for revising his own terminology (to wit: “‘Tint, Hue and Shade are employed so loosely by the public generally, even by those who claim to use English correctly, that neither word has a very definite meaning, although each is capable of being as accurately used as any other word in our every day vocabulary.’”)<sup>67</sup> Indeed, he turned to the Milton Bradley company’s assortments of colored papers when he compiled his color terms, and named two of the colors in his index “Bradley’s Blue” and “Bradley’s Violet” (Pillsbury did not get a color named for him in Ridgway’s compendium, though “Rood’s Blue,” “Rood’s Brown,” “Rood’s Lavender” and “Rood’s Violet” all make an appearance.)

Bradley’s fascination with color derived from both his commercial endeavors and a personal interest in educational reform. Born in 1836, Bradley grew up in Lowell, Massachusetts, where his father worked in the textile mills.<sup>68</sup> He briefly attended Harvard’s Lawrence Scientific School, but was forced to drop out when his

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<sup>66</sup> *Ibid.* on pg. 42.

<sup>67</sup> *Ibid.* on pg. 32.

<sup>68</sup> There are two principle biographical accounts of Milton Bradley. *Milton Bradley*, (New York, J. F. Tapley co., 1910) offers a number of recollections of Bradley and the Milton Bradley Company by friends and executives of the Bradley corporation, as well as some material by Bradley himself. James J. Shea’s *It’s All in the Game*, (New York, Putnam, 1960) is a longer and more extensively researched account of Bradley’s life, authored by the mid-twentieth century president of the Milton Bradley Corporation for the centennial of the company.

family moved to Connecticut, and shortly thereafter left home for Springfield, Massachusetts, where he sought employment as a draftsman. Early in 1860, Bradley purchased a small lithograph press with the intention of starting a printing business, but in spite of an early success selling portraits of an beardless Abraham Lincoln – an item which was passé by the time of Lincoln’s inauguration – subsequent sales were not forthcoming. Later that year, an unemployed inventor approached Bradley with the idea for a board game, which Bradley purchased, patented and produced; by 1861 “the Checkered Game of Life” was a runaway success, selling 40,000 copies in its first year and launching the Milton Bradley Company. On the success of the “Checkered Game of Life” and subsequent products – like “Games for Soldiers,” which charitable organizations bought in large quantities to send to Union forces – Bradley expanded into other areas of production.<sup>69</sup> Inspired in 1868 after attending a lecture by educational reformer Elizabeth Peabody – as well as by some passionate badgering from his neighbor, a German music teacher named Edward Wiebe – Bradley became a committed advocate of what was then a novel program of “kindergarten” education. Developed in the 1840s by the German teacher Friedrich Froebel, kindergarten (as Froebel saw it) emphasized a sort of sensual/scientific education involving the use of colorful learning implements called “gifts” – geometric shapes and patterns in bright colors, intended to introduce children to the fundamental elements of sensation.<sup>70</sup> Working with Weibe and Peabody, Bradley

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<sup>69</sup> On “Games for Soldiers” see David Wallace Adams and Victor Edmonds, “Making Your Move: The Educational Significance of the American Board Game, 1832 to 1904,” *History of Education Quarterly*, 17:4, Winter, 1977, pp. 359-383, on pg. 373.

<sup>70</sup> Norman Brosterman’s *Inventing Kindergarten*, (New York: H.N. Abrams, 1997) provides a thorough and well-illustrated history of Froebel’s kindergarten philosophy, as well as his “gifts.”

set about retooling his Springfield factory to produce Froebel's unusual educational tools – "articles [...]," recalled Bradley, "of such a character that the like of them had never before been seen in an American workshop."<sup>71</sup> In addition to wooden items, "many of the kindergartens occupations," recalled Bradley, "called for the use of colored papers, and here was a new and peculiar field of labor."<sup>72</sup> Bradley found commercially available pigments and papers to be indiscriminately identified and unreliably colored, prompting him to engage the study of color "on a scientific basis," in order to begin developing his own system of identifying and producing colors.<sup>73</sup> The result was a set of papers in ninety-one different colors that Bradley thought met the standards of color science (figure 4.2).

About John Henry Pillsbury, less can be said in detail. A man of many hats, Pillsbury was an ordained Methodist Episcopal minister, educator, botanist, and author of the 1893 textbook, *A Laboratory Guide for an Elementary Course in General Biology*; in later years he was the headmaster at a boy's school in Dedham, Massachusetts. Born in 1846, he graduated Wesleyan college in 1874, staying on for a master's degree which he earned in 1877. After teaching "natural science" in the High School in Springfield, Massachusetts between 1877 and 1881, he moved to Smith College between 1882 and 1894, where he taught "Plant Description and Analysis, Study of Types of Living Organisms, Systematic Botany, Vegetable Histology, Vegetable Physiology."<sup>74</sup> Although he may have known Ridgway through

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<sup>71</sup> Milton Bradley Co., *A Successful Man*, on pg. 32-33.

<sup>72</sup> *Ibid.* on pg. 33.

<sup>73</sup> *Ibid.*

<sup>74</sup> Biographical information on Pillsbury is rather limited. See Lora Altine Woodbury Underhill, *The Descendants of Edward Small of New England and the Allied Families with Tracings of English Ancestry*, Vol. 1 (Cambridge: Riverside Press, 1910) on pg. 124; F.W. Nicolson, *Alumni Record of Wesleyan*



meetings of the American Society of Naturalists, of which both men were members, Pillsbury recalled that the problem of color nomenclature originally came to him as early as 1880 when he noticed that female students in his high school classes tended to use many more words to “express much smaller differences in color” when naming the colors of flowers than his male students. This tendency he took to be caused by the generally “fuller vocabularies” of women, rather than a surfeit color blindness among the men, but he also noted that, while they used more words to express what they were seeing, women also tended to be less accurate in their descriptions. This realization led Pillsbury to conclude that “[w]hat we most need is not a fuller vocabulary [in naming colors] but a more accurate use of the vocabulary we now possess” – a principle that guided his experiments with color naming systems through the 1880s.<sup>75</sup>

It is not clear exactly when Bradley’s and Pillsbury’s paths crossed, nor is the precise nature and timetable of their collaboration easy to ascertain. Archival evidence on Pillsbury is limited to a smattering of items mostly pertaining to his botany work, while Bradley’s papers – including his detailed diaries and his correspondence – went missing some time in the late 1960s, with only fragments of entries remaining through excerpts in secondary sources.<sup>76</sup> Extant published pieces,

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*University, Middletown, Conn. 3rd Edition, 1881-3*, (Hartford, Conn.: The Case, Lockwood and Brainard Company, 1883) on pg. 263; on Pillsbury’s Smith College courses see:

<http://www.smith.edu/garden/Academics/courselist.html>, last accessed 4/27/2011.

<sup>75</sup> J.H. Pillsbury, “On the Color Description of Flowers,” *Botanical Gazette*, 19:1, Jan. 1894, pp. 15-18, on pg. 15.

<sup>76</sup> On Bradley’s missing diaries see Jill Lepore, “The Meaning of Life: What Milton Bradley Started,” *The New Yorker*, 83:15, 21 May 2007, pp. 38 - 41. Lepore gives a nimble take on Bradley’s “Checkered Game of Life” in the article, arguing that the game represented a characteristic and telling break in both board-gaming and American values in the mid nineteenth century – in contrast with its predecessors, gameplay in “The Checkered Game of Life” focused on making money rather than

meanwhile – such as journal articles by Pillsbury and recollections by Bradley’s associates – indicate some measure of crossed purposes and chronological confusion between the two men. For example, in articles published in scientific journals in the 1890s, Pillsbury emphasized that he first became interested in scientific color names in 1880s – a declaration consistent with his statement that he came to his color work through his experiences teaching high school, which appear to have been concentrated between 1877 and 1881. However, while Pillsbury claimed in an article published in *Nature* in 1895 that he had experimentally identified the spectral wavelengths of his principle named-colors by 1884, thus cinching his nomenclatural system, this statement contradicted earlier remarks in an 1893 article in *Science* in which Pillsbury reported that he had only within the past year (i.e. 1892 or 1893) analyzed the spectral components of his color system through the loan of equipment in the physics laboratory at Wesleyan. As for Bradley’s work with Pillsbury, Pillsbury in 1892 remembered that their collaboration had ensued about “twelve or thirteen years since” – that is, around 1879 or 1880. A close associate of Bradley’s, however, remembered Bradley beginning his work in color science around 1887 – a date more consistent with the release of Bradley’s colored paper series in the early 1890s, as well as the 1892-1895 publication dates of journal articles both by Pillsbury and Bradley.<sup>77</sup> Indeed, Bradley’s biographers and Bradley himself mention collaboration in color work between Bradley and “scientists and teachers” in the Springfield school district

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moral development. Adams and Edmonds make much the same argument as Lepore about the meaning of “The Checkered Game of Life” vis-à-vis other board games in “Making Your Move: The Educational Significance of the American Board Game.”

<sup>77</sup> Milton Bradley Co., *A Successful Man*, on pg. 44.

around 1887 – indicating a possible time and place where Bradley and Pillsbury might have met over a similar interest in color nomenclature. But while Pillsbury made frequent mention of Bradley in his published work, Bradley acknowledged Pillsbury only once in his published writings, in an 1893 letter to *Science* in which he endeavored to distance himself from “any misapprehension of the claims” that Pillsbury had made for their color system.<sup>78</sup> It is possible, then, that Bradley and Pillsbury were both at work on the question of color names throughout the 1880s, but beginning in earnest in the 1890s, though it is equally possible that Pillsbury’s recollections of thinking about color in the 1880s were an attempt to give retroactive precedence to his own work over color systems like those of Ridgway – or, for that matter, his own collaborator, Bradley. In any case, it is difficult to say with any certainty when, precisely, Bradley and Pillsbury began to work on their system, or precisely how they collaborated.

What is clear is that both Bradley and Pillsbury, like Ridgway, put a premium on precision in color naming. As Pillsbury lamented in 1895, although musical notes and geometrical forms could be symbolically notated with great accuracy – i.e. through notes and measurements, “for colour perceptions we have neither any well-defined concepts for those terms which have become well-established, nor any definitely and well-arranged system of colour terms for common use.”<sup>79</sup> Bradley, for his part, struck a somewhat apocalyptic tone, lamenting that “geometrical forms have already been so definitely analyzed by the science of mathematics that if destroyed to-day [sic] these solids and surfaces could be reconstructed at any future

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<sup>78</sup> Milton Bradley, “The Color Question Again” *Science*, 19:477, 25 Mar. 1892, pp. 175-176, on pg. 175.

<sup>79</sup> J.H. Pillsbury, “A Scheme of Colour Standards,” *Nature*, 22 Aug 1895, on pg. 390.

time from written or printed directions. But suppose all material samples of color to be lost, it would be impossible by the ordinary system of color nomenclature to even approximately restore a single one from written or verbal descriptions.”<sup>80</sup> Faced with the fantastic possibility of a cataclysmic and rather inexplicable loss of all colors, the need to accurately define and communicate colors through text that could be preserved and restored at will attained a high priority.

But unlike Ridgway, instead of basing their color terms in the names of objects and people, Bradley and Pillsbury advocated a more precise usage of a smaller number of abstract color terms. Gone were the fanciful “dragon’s blood,” “broccoli brown” and “isabelle” of Ridgway’s abacadarius – terms which, along with the much-maligned “elephant’s breath,” Bradley found “meaningless,” and Pillsbury felt to be simply “absurd.”<sup>81</sup> Gone, too, were names based on popular pigments – even those such as “vermillion” and “ultramarine” which, although “used by many of our best authorities on colour,” were nevertheless subject to a “wide range of variation.”<sup>82</sup> Nor was there any place in the two men’s system for commonplace color words like “olive, citrine, russet, &c.,” which Pillsbury dismissed as “terms whose meaning has never reached any considerable degree of accuracy.”<sup>83</sup> Pillsbury even gave the axe to indigo – a staple of optical discourse since Newton included it in his divisions of the spectrum in 1671 – on the grounds that “the always questionable indigo of the rainbow is no longer recognized as one of the distinct

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<sup>80</sup> Bradley, *Elementary Color*, on pg. 6.

<sup>81</sup> Bradley quoted in Shea, *It’s All in the Game*, on pg. 114.

<sup>82</sup> Pillsbury, “A Scheme of Colour Standards,” on pg. 390.

<sup>83</sup> *Ibid.*

spectrum colors.”<sup>84</sup> (In this, Pillsbury was perhaps following Rood, who, in one of his few forays into color terminology, objected to indigo’s inclusions among the colors of the spectrum on the grounds that, on the one hand, goods dyed with the pigment matter called indigo tended really to be more greenish blue than the spectral zone that the term “indigo” indicated, while on the other, cakes of raw indigo pigment tended to be much darker than spectral indigo. In Rood’s opinion, “Prussian Blue” was both a term and a pigment that better represented the “indigo” part of the solar spectrum.)<sup>85</sup>

Rather than “scouring the field of literature for fanciful and arbitrary names,” as Bradley put it, he and Pillsbury advocated a systematic color nomenclature based on only six color terms – “red,” “orange,” “yellow,” “green,” “blue” and “violet,” the latter of which Pillsbury favored over “purple” because he felt that, strictly speaking, “purple” indicated a combination of red and violet.<sup>86</sup> Along with black and white – which Bradley and Pillsbury termed “shade” and “tint,” respectively – disks of these colors could be combined on a color wheel to represent any color sensation imaginable. The names of these combined colors, meanwhile, could be expressed as simple assemblies of the principle words for colors, or even an abbreviation of the terms. Thus a color that appeared to be an equal mixture of black and red could be notated as “red shade No. 1,” or simply “R.S.” A color between red and orange but leaning towards the latter would be Red Orange, or R.O.; a color between red and

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<sup>84</sup> *Ibid.*

<sup>85</sup> Ogden Rood, “On Newton’s Use of the Term Indigo, etc.” *American Journal of Science and Arts*, Vol. XIX, 1879, p. 135.

<sup>86</sup> Bradley quoted in Shea, *It’s All in the Game*, on pg. 123; Pillsbury, “On the Color Description of Flowers,” on pg. 18.

orange but leaning towards the former would be Orange Red or O.R. (Pillsbury and Bradley's abbreviation convention did not account for a color exactly between red and orange). By placing a slightly larger disk divided into 100 sections behind the colored sections, it was moreover easy to specify the exact percentages of the basic hues that constituted a specific color. Thus "Orange Red" might more specifically be called O.25 R.75, while a sample of a commercial color like "crushed strawberry," instead of being conventionally described as "a dull, slightly orangish pink," could, through comparison with a spinning disk bearing the correct standard colors in the correct proportions, be rewritten as "R55, O5, W 27, N 11" – or 55% red, 5% orange, 27% white and 11% black.<sup>87</sup> "What a saving of confusion in the use of color names is thus gained," exclaimed Pillsbury, "we are hardly able to realize."<sup>88</sup>

In itself, Pillsbury and Bradley's idea was not especially novel. Colloquial English furnished roughly the same convention as their suggested nomenclature without the need of spinning disks. A color like that of a lime, for instance, might simply be described as "yellowish green" in everyday language, while a color like that of rust could be called "orangeish red." Moreover, two color systems similar to theirs already existed by the early 1890s. After reading an 1895 article by Pillsbury describing his and Bradley's color notation, Herbert Spencer, the British social scientist, wrote to *Nature* to say that he had already thought of a similar system, based on the compass, such that different combinations of red and blue might be notated as "red by blue, red-red-blue, red-blue by red, red-blue (purple); red-blue

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<sup>87</sup> Pillsbury, "The Nomenclature of Colours," on pg. 57.

<sup>88</sup> *Ibid.* on pg. 55.

by blue; blue-red blue, [and] blue by red.”<sup>89</sup> While allowing that his system didn’t have the same degree of “scientific nicety of discrimination or naming” that Pillsbury’s did, Spencer nevertheless remarked that “[v]ery possibly, or even probably, this idea has occurred to others, for it is a very obvious one.”<sup>90</sup> Pillsbury himself affirmed Herbert’s suspicion, writing in response that not only had he (Pillsbury) used the metaphor of a compass in an 1890 lecture given to the American Association for the Advancement of Science (again suggesting a much later date to Pillsbury’s work than others of his own accounts), but that such a system had also been put to use by Louis Prang, a Boston-based printer and paper manufacturer, who used a nomenclature similar to his and Bradley’s – “R RRO ORO O OYO YO YYO Y, &c,” for example, to signify different colors between pure red and pure yellow.<sup>91</sup> Immediately below Pillsbury’s response, the editors of *Nature* included a letter from Louis Prang himself, also claiming credit for a “system of colour nomenclature” that “corresponds almost precisely to the idea in Mr. Spencer’s mind.”<sup>92</sup> Whatever the originality of the idea, the editors of *Nature* concluded, they were “glad to see that the idea has been put into practice, and that, out of a chaos of colour-names, an intelligent system of nomenclature had been evolved.”<sup>93</sup>

But Bradley and Pillsbury’s system – the two men insisted – was of a different caliber than those proposed by Spencer and Prang. Rather than an

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<sup>89</sup> Herbert Spencer, “The Nomenclature of Colours,” *Nature*, 1348:52, 29 Aug. 1895, pg. 413.

<sup>90</sup> *Ibid.*

<sup>91</sup> Pillsbury, “The Nomenclature of Colours,” on pg. 55.

<sup>92</sup> Louis Prang, “The Nomenclature of Colours,” *Nature*, 1360:53, 21 Nov. 1895, pp. 55-56, on pg. 56.

<sup>93</sup> Unsigned Editorial (Norman Lockyer?), “The Nomenclature of Colours,” *Nature*, 1360:53, 21 Nov. 1895, pp. 55-56, on pg. 56.

essentially arbitrary allocation of color terms, it represented a color *standard*, fixed not to any object or pigment, but to precise points on the solar spectrum. “The wave theory of light,” explained Pillsbury, “long ago established the fact that vibrations of an almost infinite variety of wave length in the luminiferous ether impinge upon the human retina and produce the effect which we call white light. From these [infinite combinations of wavelengths] we may select any wave-length we please, and giving it a name, have a colour as accurately fixed as any musical note or geometrical form.”<sup>94</sup> The notion of dealing with color strictly as a physical phenomenon rather than as a quality of objects appears to have met with some resistance. “It has been urged in objection to the spectrum colors that they are not the colors of nature,” wrote Pillsbury in 1893 – a criticism that he countered with the somewhat gnostic observation that, in fact, “nature has no other colors than those of the spectrum.”<sup>95</sup> That is, from a physical perspective, all colors necessarily derived from the variable absorption and reflection of different frequencies of solar light. Unlike objects – lemons, for instance, with their individual particularities – the wavelengths of light represented in the solar spectrum were, as Bradley stated, “unalterably fixed.”<sup>96</sup> Thus, wrote Pillsbury, it was “possible to ascertain or relocate the [color] standard in any part of the world without any material representation of the color designated.”<sup>97</sup>

Bradley and Pillsbury were pleased with their system – Bradley managed to include two of his pet projects in a single boast when he wrote in his memoir about

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<sup>94</sup> J.H. Pillsbury, “A Scheme of Colour Standards,” *Nature*, 22 Aug. 1895, on pg. 390.

<sup>95</sup> J. H. Pillsbury, “The Standard Color Scheme,” *Science*, 21:540, 9 Jun. 1893, pp. 310-311.

<sup>96</sup> Bradley quoted in Milton Bradley Co., *A Successful Man*, on pg. 34.

<sup>97</sup> Pillsbury, “A Scheme of Colour Standards,” on pg. 390.



“the immense improvement in one department of physics,” that he had fostered, “growing out of the introduction of the kindergarten.”<sup>98</sup> But Bradley and Pillsbury’s system raised some important questions, too. First, even if spectral colors were the true “colors of nature,” what warranted the selection of one wavelength in the nominally “red” band of the spectrum over another? Wasn’t picking a wavelength, as Pillsbury had suggested, just as arbitrary as picking a colored object upon which to base one’s color nomenclature? And second, what precise claim were Bradley and Pillsbury making about their colored disks? Were colored disks not just objects, rather like lemons, subject to greater or lesser deviation from a sensual norm?

To answer this first question, Pillsbury and Bradley relied on a panel of experts (a “small company of scientists and teachers,” in Bradley’s recollection; “six or eight persons well skilled in the use of colours,” in Pillsbury’s) who were invited to pinpoint the exact position of each of the six color terms on a large prismatic spectrum projected on a screen in the Springfield High School.<sup>99</sup> Among the assembled panel was the art educator Henry T. Bailey, soon to be named State Director of Drawing in Massachusetts, who later recalled being invited by Bradley into a “dark room, with its quivering spectrum of glory, ten feet long.”<sup>100</sup> Somewhat to Pillsbury’s surprise, correlating precise points in the spectrum with abstract colloquial color terms was a relatively straightforward task. Rather than expressing a wide range of opinion as to the best exemplar of red, orange, yellow, etc. in the spectrum, the panel exhibited a “very great unanimity of judgment” – suggesting to

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<sup>98</sup> Milton Bradley Co., *A Successful Man*, on pg. 34.

<sup>99</sup> Milton Bradley Co., *A Successful Man*, on pg. 34; Pillsbury, “A Scheme of Colour Standards,” on pg. 390.

<sup>100</sup> Milton Bradley Co., *A Successful Man*, on pg. 32-33.

Pillsbury that abstract color terms did, in fact, signify something more universal than the subjective judgments of individual viewers.<sup>101</sup> Indeed, this is what Ridgway meant in his 1912 *Nomenclature of Colors* when, following Pillsbury and Bradley, he described “Red, Orange, Yellow, Green, Blue and Violet” as the “psychologically distinct colors of the solar spectrum” – implying that the words indicated generally recognized and precisely defined sensations regardless of the material origins of those sensations.<sup>102</sup> Once identified as distinct and meaningful areas of the solar spectrum, Pillsbury set about cementing the definitions of his color words in terms of wavelengths, which he identified (in microns) as: Red .6587; Orange .6085; Yellow .5793; Green .5164; Blue .4695; Violet .4210.<sup>103</sup> Thus Bradley and Pillsbury could reasonably argue that their system was not “arbitrary” or subject to the vagaries of the “human equation” (as Ridgway had put it) but rather provided a physically precise concretization of meanings of abstract color terms in English.

The question of the ontological status of Bradley and Pillsbury’s colored disks followed from their work in defining salient abstract color words in terms of spectral wavelength. Both Bradley and Pillsbury acknowledged that, speaking strictly according to the principles of psychophysics, only three colors – red, green, and a bluish purple – ought to be used as bases of a color system. Nevertheless, as Bradley explained, “[i]nstead of beginning with three primary colors seen in the

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<sup>101</sup> Pillsbury, “A Scheme of Colour Standards,” on pg. 390.

<sup>102</sup> Ridgway, *Color Standards*, 1912, on pg. 19.

<sup>103</sup> See, e.g. Pillsbury, “A Scheme of Colour Standards,” on pg. 390. On use of Wesleyan’s physics lab, see Pillsbury, “The Standard Color Scheme,” on pg. 310. The report for the American Association for the Advancement of Science’s 1895 meeting lists Pillsbury’s spectral value for green as “.4156” microns – probably a typo. See Pillsbury, “On Standard Colors,” in *Proceedings of the American Association for the Advancement of Science for the Forty-Fourth Meeting held at Springfield Mass.* (Salem: Published by the Permanent Secretary, 1885) pp. 58-59, on pg. 59.

spectrum we are content to select six.” By choosing six colors “as they appear in the spectrum [and] making the best imitations of them possible with pigments,” their system “practically bridge[d] the chasm between the science of color and the practice of color in the use of pigments.”<sup>104</sup> That is, the physical basis of their system of color nomenclature was a conceit, to be sure, but one in which, as Bradley put it, each color term was “definitely located in the solar spectrum by the wave length of each *material color* as matched in the spectrum.”<sup>105</sup> The colored disks were a fiction, but one which closely enough approximated both the psychophysics of color mixing and the conventional definition of abstract English color terms that Bradley felt they worked, themselves, as sorts of universal objects. In effect, Bradley and Pillsbury asked their viewers to believe that his disks were archetypal abstractions of the sensations referred to by color terms, rather than particular colored objects. Unlike Ridgway’s color naming system, Bradley and Pillsbury’s system was based on the idea that a color – like “crushed strawberry” – was ultimately a numerically definite conglomeration of discrete sensations, rather than a representation of an actual macerated strawberry somewhere in the world. As such, the disks were not disks at all, but representatives of entangled pairs of names and sensations, rather than of sensations, names, and objects.

Bradley and Pillsbury further explained this profound reordering of the physical, sensual and nominal aspects of color perception in their discussions of the possible applications for their color system. For example, Pillsbury mused, imagine that “a firm dealing in large quantities of coloured material” wanted to manufacture

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<sup>104</sup> Bradley, “The Color Question Again,” on pg. 175.

<sup>105</sup> Milton Bradley Co., *A Successful Man*, on pg. 40, italics added.

a new color. "By the old method," Pillsbury explained, "they must find something as nearly like what is desired as possible, and then dictate the variations that are to be made." Equipped with colored disks corresponding to Bradley and Pillsbury's system, however (or even equipped with the means to produce colored disks of the associated spectral wavelength), the firm could simply compose the desired color on their color wheel, and then send the formula to their manufacturer, "who also has a set of the disks, and he 'sets up the colour' and then reproduces it in the material desired."<sup>106</sup> Indeed, if a salesperson were in doubt about what a customer wanted, could simply "tak[e] him to the colour wheel and ascertain what the desired colour is," and then send the information on to his manufacturer. Rather than relying on comparisons with colored objects to compose a novel prospective color, that is, Bradley and Pillsbury's system dispensed with the need for particular colored objects in favor of precise terms for colors. Such a system, moreover, was well suited for pairing with modern technologies, dramatizing both its fantastic utility and eerie dissociation from the material world. "As a manufacturer of an extended line of colored papers," remarked Bradley,

"I am constantly putting this proposed nomenclature to a severe test by ordering new colors by telephone. That is to say, we make the desired combinations on the wheel in our office and then telephone them to the factory, ten miles distant, where they are again made on the wheel and the papers are then manufactured to correspond with the results of these combinations. Under this plan we are liable to have occasion to 'telephone a

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<sup>106</sup> Pillsbury, "A Scheme of Colour Standards," on pg. 392.

color' frequently. In the same way we could cable colors to Europe should it be necessary."<sup>107</sup>

Not only did Bradley and Pillsbury conceive of color as distinct from colored *things* – color could, in fact, be decomposed into something as immaterial and impersonal as pulses of electricity creeping their way across the Atlantic seabed, only to be reconstituted whole minutes and thousands of miles away.

Other than Bradley's professed usage of the color nomenclature to telephone color, there is little evidence that Bradley and Pillsbury's nomenclature was widely adopted. Although Pillsbury announced at the 1895 meeting of the American Association for the Advancement of Science that Hallock and Gordon, editors of the *Standard Dictionary*, had used his and Bradley's system when defining colors in their lexicon, Hallock and Gordon quickly penned a firm rebuttal. While acknowledging that "the scientific method [for naming standard colors] would seem to be to choose from the spectrum itself and locate those colors ideally," Hallock and Gordon wondered if it was truly possible to accurately and consistently reproduce spectral colors with pigments. "Chromolithography can do wonders and can nearly match a spectrum color," they admitted. "The objection, however, to such working standards is that each lithographer, and indeed the same one at different times, will succeed to different degrees, so that a slight variation in color, luminosity and saturation is inevitable."<sup>108</sup> For this reason, Hallock and Gordon wrote, "we have no desire to belittle the work of Milton Bradley or Mr. Pillsbury, for they are doing much for the introduction of scientific methods into color study, but it did not seem

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<sup>107</sup> Bradley, "The Color Question Again," on pg. 176.

<sup>108</sup> Hallock and Gordon, "Color Standards," on pg. 214.

best to us to attempt to define all colors [i.e. in composing the entries for colors in the *Standard Dictionary*], using only two colored discs at a time, and we do not believe that any lithographed surfaces should be adopted as ultimate standards, even though they may prove best adapted to educational purposes.”<sup>109</sup> “No doubt Mr. Pillsbury regretted that his system was not adopted for the ' Standard Dictionary,” they continued, “but that should not have induced him to insinuate that we copied his system.”<sup>110</sup> For the *Standard Dictionary*, Hallock and Gordon relied instead on the colors of common pigments – recapitulating the problems of Ridgway’s nomenclature, but comfortably rooting their system in the material world.

### The Logician

Although Bradley and Pillsbury felt that their color nomenclature definitively established the relationship between spectral colors and color names, others were not so sure. Particularly for scientists working in the emerging discipline of psychology, such as Christine Ladd-Franklin, the linkages between the objective world, the sensing body, and the spoken word defied one-to-one correspondence. “The universe in which we find ourselves,” she wrote in undated notes, “consists of three regions, the physical, the intracorporeal and the extracorporeal. Color phenomena, like other phenomenon of the conscious organism include in the first place the physical, in the last place the psychical, and in the middle place the

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<sup>109</sup> *Ibid.* on pg. 215.

<sup>110</sup> *Ibid.*

physiological.”<sup>111</sup> This, in itself, was not so different from the unspoken assumption made by Bradley and Pillsbury – as well as, for that matter, as psychophysicists such as Rood – that to understand vision, one had to take into account not only color as objectively defined by physics, but also the subjective physiological response of the observer. But how those objective stimuli and physiological responses came to be understood as singular experiences in “the last place” – that is, the “psychical” or the “extracorporeal” – was exceedingly difficult to discern. In notes entitled “Poor Nature!” Ladd-Franklin lamented the “defective” connection between “prismatic colors” as studied by physicists in laboratories and colors as experienced in everyday life. “The color sensations,” she wrote, “are in any case, a representation *in the consciousness* of the facts of an external world – a sad makeshift.”<sup>112</sup> Unlike the conscious apprehension of sound – and in particular music, in which auditors could apparently discern and describe with effortless clarity distinct transitions between notes within an octave – the colors of the prism were vexingly hard to label with any sort of reliability. “The sense organ in color is acute enough to enable us to distinguish, in the visible spectrum, 150 different sensations,” exclaimed Ladd-Franklin. And yet, those “different sensations are for the most part merely “blends” in different proportions [of “unitary” colors].”<sup>113</sup> Nature had perpetrated a fraud on sentient beings, Ladd-Franklin continued, although the purpose was unclear. “Why

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<sup>111</sup> Christine Ladd-Franklin, Undated Notes, Box 53: Folder: methodology, Ms Coll Franklin, Christine Ladd-Franklin and Fabian Franklin Papers, Library of Rare Books and Special Collections, Columbia University.

<sup>112</sup> Christine Ladd-Franklin, Undated Notes, Box 54: Folder: Prismatic Colors, MS Coll Franklin, Christine Ladd-Franklin and Fabian Franklin Papers, Library of Rare Books and Special Collections, Columbia University.

<sup>113</sup> Christine Ladd-Franklin, Undated Notes, Box 54: Folder: Prismatic Colors, MS Coll Franklin, Christine Ladd-Franklin and Fabian Franklin Papers, Library of Rare Books and Special Collections, Columbia University.

this deception on the part of nature?" she wondered. "It can only be that, having started on a certain (chemical) plan for a physical and psychological representative of a non specific whole octave general band of a physical light she found nothing better to do than what she has done, defective as it is!"<sup>114</sup> The simple relationship implied by Bradley and Pillsbury, that is, between physical stimulus, sensual response, and conscious description, was far more muddled than they had assumed.

In order to untangle the "defective" relationship between stimulus, response and cognition, Ladd-Franklin relied on "introspection" – a central technique of the so-called structuralist school of psychology, then enjoying a brief moment of popularity in the United States. Although practitioners argued as to the precise scope and methods of introspection, at its most basic introspective psychology consisted simply of "looking into our own minds and reporting what we there discover," as William James famously put it.<sup>115</sup> Just as psychophysics plumbed the associations between physical sensations and physiological responses, introspective psychologists probed the relationships between physiological responses and conscious thoughts. As such, the "physical," "intracorporeal," and "extracorporeal" regions of Ladd-Franklin – while entwined in ways that defied simple correspondence between physical stimulus, physiological response, and cognitive perception – were not mutually exclusive areas of study. Indeed, physics was simply concerned with understanding the nature of the objective world as experienced and reported by the observer, while psychology was concerned with understanding the

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<sup>114</sup> Box 54: Folder: Prismatic Colors, MS Coll Franklin, Christine Ladd-Franklin and Fabian Franklin Papers, Library of Rare Books and Special Collections, Columbia University.

<sup>115</sup> William James, *Principles of Psychology* (Cambridge: Harvard University Press, 1983:1890) on pg. 185.



nature of the mind as experienced and reported by the observer. The only difference was that physics effaced the observer through abstract measurement; while psychology made the observer its central object of study.<sup>116</sup> In an undated note marked “a faire,” for example, Ladd-Franklin described an introspective experiment to compare ocular discrimination in two [series] of color gradients: “get a long good bk-wh series, + by its side a long, good bk – gr series. Sit down before them and by introspection see if they are or are not similar series.”<sup>117</sup> Different schools of psychologists set different parameters for acceptable technique – strict experimental psychologists in the vein of Wilhelm Wundt or Edward Titchener would question whether describing “similarity” was truly an introspective function, or a function of higher-order judgment – but in broad strokes, as the historian of psychology Edwin Boring put it, introspection was predicated upon the “belief that the description of the consciousness reveals complexes that are constituted of patterns of sensory elements.”<sup>118</sup> It was these complexes – these deep structures of physical, physiological and psychical interactions – that the study of color promised to illuminate.

As such, for Ladd-Franklin, the words used by people to describe colors were of central importance not for defining the properties of objects, but for defining the

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<sup>116</sup> See Boring, Edwin G. Boring, “A History of Introspection,” *Psychological Bulletin*, 50: 3, May 1953, pp. 169 – 189, on pp. 171-172. Deborah J. Coon writes about introspection an attempt to mirror methods of industrial production in “Standardizing the Subject: Experimental Psychologists, Introspection, and the Quest for a Techno scientific Ideal,” *Technology and Culture*, 34: 4, Oct. 1993, pp. 757-783; see also Kurt Danziger, “The History of Introspection Reconsidered,” *Journal of the History of the Behavioral Sciences*, 16, 1980, pp. 241-62.

<sup>117</sup> Christine Ladd-Franklin, Undated Notes, Box: 50, Folder: Experiment to do re: vision, MS Coll Franklin, Christine Ladd-Franklin and Fabian Franklin Papers, Library of Rare Books and Special Collections, Columbia University.

<sup>118</sup> Boring, “A History of Introspection,” on pp. 171-172.

inner workings of the human mind. Rather than asking how properly to notate the millions of sensations that humans could discern, she instead asked why human beings could experience millions of colors but define only a very few? What did this fact – and the facts that were known about physiological and psychological responses to color – say about the relationship between sensation and cognition? And how ought this relationship be understood in a society based on the precepts of science?

Ladd-Franklin arrived at her color science obliquely. Born in 1847 in Windsor, Connecticut, she grew up in what her biographers roundly describe as a well-off and progressive family.<sup>119</sup> Her mother and aunt were energetic advocates of women's rights; and her father, a successful businessman, was unusually supportive of his daughter's intellectual curiosity (though he did worry, in line with the thinking of the day, that excessive scholarly exertion might impair her physical and mental well-being).<sup>120</sup> Ladd-Franklin recalled that when she was an undergraduate at Vassar between 1866 and 1869, women were denied access to the laboratory equipment necessary to study her principle interest, physics, so she turned to "the next best subject, mathematics, which could be carried on without any apparatus."<sup>121</sup> After finishing Vassar and teaching elementary school for nine years,

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<sup>119</sup> For biographical information on Ladd-Franklin, see Laurel Furumoto, "Joining Separate Spheres: Christine Ladd-Franklin, Woman Scientist (1847-1930)," *American Psychologist*, Feb. 1992, pp. 175-182; and Laurel Furumoto, "Christine Ladd-Franklin's Color Theory: Strategy for Claiming Scientific Authority?" *Annals of the New York Academy of Sciences*, Vol. 727, Oct. 1994, pp. 91-100. For an account of Ladd-Franklin's life from a fellow color scientist see Dorothea Jameson Hurvich, "Christine Ladd-Franklin," in Edward T. James, Janet Wilson James, Paul S. Boyer, eds., *Notable American Women*, Vol. 3, Cambridge: Belknap Press, 1971, pp. 354-356.

<sup>120</sup> Furumoto, "Joining Separate Spheres" on pg. 179.

<sup>121</sup> "Christine Ladd-Franklin," *Biographical Cyclopedia of American Women*, Vol. 3. (New York: Halvord Publication Co., 1928) pp. 135-141, on pg. 136.

she went on to do graduate work in logic with Charles Peirce at Johns Hopkins University, publishing her thesis, "On the Algebra of Logic," in 1883 as part of a compendium of the works of Peirce's students.<sup>122</sup> While at Johns Hopkins, she became interested in the problem of the "horopter" – the geometrical form defining the field of binocular vision – publishing a study of the phenomenon in 1889.<sup>123</sup> Two years later, while accompanying her husband (also a mathematician) on a sabbatical in Germany, she pursued her vision work at the laboratory of George Elias Müller, an experimental psychologist known for his work in color and memory studies. Later that year, she traveled from Gottingen to Berlin to do further work in the laboratories of Helmholtz, where she worked with his disciple, Arthur König, on measuring the "basic sensations" (*Grundempfindungen*) of normal and color-blind vision.<sup>124</sup>

It was during this time in Germany that Ladd-Franklin was first exposed to a wide-ranging scientific dispute between partisans of Helmholtz and followers of the German physiologist, Ewald Hering, over the nature of the functioning of the color sense. Helmholtz, as was well known among physicists and physiologists alike in the United States and Europe, had proposed since the middle of the 1850s that all color sensations arose through the reactions of three sorts of cells in the retina of the observer, each sensitive to either red, green or blue light; the variable responses of these cells to different sorts of visual stimuli combined in the mind of the observer

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<sup>122</sup> Christine Ladd-Franklin, "On the Algebra of Logic," in *Studies in Logic*, ed. Charles S. Peirce (Boston: Little, Brown and Company, 1883) pp. 17-61.

<sup>123</sup> Christine Ladd-Franklin, "The Experimental Determination of the Horopter," *American Journal of Psychology*, 1, 1889, on pp. 99-111.

<sup>124</sup> Arthur König, "Die Grundempfindungen in normalen und anomalen Farbsystemen und ihre Intensitätsvertheilung im Spectrum," *Zeitschrift für Psychologie und Physiologie der Sinnesorgane*, 1892, pp. 241-347.

to yield the vast multiplicity of sensations that people experienced as color. In 1864, however, Ewald Hering, an German physiologist, challenged Helmholtz's theory, proposing that color sensations were not, in fact, the result of three retinal receptors each keyed to *one* color, but rather three receptors that reacted antagonistically to *paired sets* of colors, such that one kind of receptor responded to red/green; one responded to yellow/blue; and one to black/white. According to Hering, it was the variable responses of these three sorts of receptors as they oscillated between their "opponent" pairs – and not the simple combination of three sorts of fixed responses – that the brain of the observer combined to yield a sensation of color.

As historian R. Steven Turner points out, more was at stake than simply the precise mechanism by which color sensations manifested themselves – Helmholtz's and Hering's theories implied not only different physiological mechanisms, but also very different methodologies for understanding sensation, and very different models for thinking about human beings as a subject of science.<sup>125</sup> Among many other arguments, Helmholtz's followers pointed to the increasingly precise and well-replicated experiments made in psychophysical laboratories with spinning disks and combinations of spectral light. These seemed incontrovertibly to prove that red, green and blue lights were the sole ingredients necessary to produce all color sensations, including non-colors such as white and black – the former of which was viewed as a state of maximal stimulation of all three varieties of receptor cells, while

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<sup>125</sup> Turner examines the dispute between Hering and Helmholtz from an STS "conflict studies" perspective, emphasizing that the Helmholtz-Hering controversy was not simply a matter of comparing facts, but of marshalling schools of allies for support. R. Steven Turner, *In the Eye's Mind: Vision and the Helmholtz-Hering Controversy* (Princeton: Princeton University Press, 1994). A shorter version of Turner's basic argument can be found in R. Steven Turner, "Vision Studies in Germany: Helmholtz versus Hering," *Osiris*, Vol. 8, 1993, pp. 80-103.

the latter was viewed as a state of non-sensation. Hering's theories appeared to Helmholtz and his supporters to be overly hypothetical and idealistic – founded on pie-in-the-sky speculation underpinned by flimsy evidence at best. Proponents of Hering's view countered that Helmholtz's model of vision was overly mechanistic and incomplete. On the one hand, it posited a human organism that simply experienced the world as a series of inputs and outputs, with none of the dynamism of Hering's notion of opponency, while on the other hand it dismissed phenomena that didn't fit its parameters as products of "the psychological," and therefore, by implication, the unknowable. If Hering's theory lacked the sort of physical rigor that Helmholtz's seemed to supply, Hering's partisans countered that Helmholtz's theory neither accounted for well-known aspects of perception such as the apparent impossibility of certain color combinations such as greenish-red or bluish-yellow (which Hering's supporters thought neutralized each other to form gray) nor did it properly account for its assertion that colors like white and black were, in fact, qualitatively different sensations from those like red and green. Although seldom rehearsed in the United States – where Helmholtz's domination was secure until at least the First World War – arguments between the two factions remained vigorous in Europe throughout the nineteenth century and until Hering's death in 1918.

By the time of her year in Germany, arguments between the two factions were in full swing, giving Ladd-Franklin ample opportunity to consider each theory with care, before pronouncing both sides guilty of committing "crime[s] against the spirit of science." Although over the next three decades she occasionally vacillated as to which side was the more heinous offender, her basic criticisms of both

Helmholtz's and Hering's partisans remained consistent. Of Hering's followers, she fumed, "[a]lthough this great body of facts [about Helmholtz's trichromatic theory] is absolutely inexpugnable, although they involve a great mass of color mixing and of color mixture equations, carried out by instruments of absolute precision, repeated in laboratory after laboratory, and always with reconfirmation – although, I repeat, these facts are indubitable facts, the follows of Hering are obliged, by the terms of their theory, to shut their eyes to them."<sup>126</sup> Their "errors" she wrote, "consist in most sinful commissions" – they simply ignored experimental evidence, which ran contrary to their theory. But Helmholtz and his followers were no less sinful. Although they could point to a great mass of experimental evidence to bolster their theory, they failed to look *beyond* their experiments to their own experiences of color. They failed, that is, to "introspect," and in doing so missed a very important fact about color sensations: according to Helmholtz's theory, yellow wasn't a primary color because it consisted of the optical combination of red and green light – a fact well-rehearsed in countless psychophysical experiments.<sup>127</sup> However, as evidenced by basic color terminology (at least in both English and German), human beings don't call yellow "reddish-green;" they call it "yellow" – that is, its own, singular name, suggesting to Ladd-Franklin that it was a "unitary" color or "unitary" sensation – a sensation with enough psychological salience to warrant a specific

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<sup>126</sup> Christine Ladd-Franklin, Undated Notes, BOX 51: Folder: Color Triangle, MS Coll Franklin, Christine Ladd-Franklin and Fabian Franklin Papers, Library of Rare Books and Special Collections, Columbia University.

<sup>127</sup> Christine Ladd-Franklin, Undated Notes, Box 50: Folder Contra Hering, MS Coll Franklin, Christine Ladd-Franklin and Fabian Franklin Papers, Library of Rare Books and Special Collections, Columbia University. In fairness to Hering and his followers, Ladd-Franklin later reversed herself, writing that "[t]he theory of Hering [...] is so vastly superior to the Young-Helmholtz theory, that until it has fully displaced that it is hardly desirable to discuss its demerits" (Christine Ladd-Franklin, *Colour and Colour Theories*, London: Kegan Paul, Trench, Trubner & Co, 1929, on pg. 45).

linguistic denomination. Thus while both Helmholtz and Hering's theories accounted well for different *aspects* of color vision, neither could account for the total structure of visual experience as reported verbally by careful observers.

Having diagnosed the deficiencies in the two dominant theories of color vision of nineteenth century science, Ladd-Franklin did not hesitate to propose her own, which she first read in 1892 at the International Congress of Experimental Psychology in London and published thereafter both in the *Proceedings* of the conference, and the American journal, *Science*.<sup>128</sup> The "development," "evolutionary," or "genetic" theory of color perception, as she variously called it, posited that rather than three different sorts of receptor cells with either singular or paired color responses, the evidence collected by Helmholtz and Hering – when considered jointly – indicated that there was only one color-sensing *molecule* within the cells of the retina, which was responsible for generating all color sensations as well as sensations of light and dark. This molecule, she proposed, had been responsible for rudimentary vision early in the evolution of the visual apparatus of living things, and slowly changed over time, developing different "decompositions" for different combinations of unitary colors. At first, the molecule was only capable of discharging one variety of its "exciting substance," albeit in varying degrees, thus producing graded sensations of light and dark. Later, the molecule underwent a transformation, causing it to disintegrate partially in blue light, and partially in yellow light – if struck by light of either wavelength, it would discharge its exciting

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<sup>128</sup> Christine Ladd-Franklin, "A New Theory of Light Sensation," *Science*, 22: 545, 14 Jul. 1893, pp. 18-19; Christine Ladd-Franklin, "A New Theory of Light Sensation," *Proceedings of the International Congress of Experimental Psychology, London, 1892*, pp. 103-108.

substance to a degree matching the proportion of colored light; if struck by both blue and yellow light it would discharge as a degree of light or dark. Still later in its development, the yellow aspect of the molecule further decomposed so as to yield variable responses to red and green light. As with the decomposition of the original molecule into yellow and blue, so too, red and green light could either variably decompose the yellow aspect of the molecule into red or green sensations, or – if they struck the molecule in the correct proportions – would be experienced by the viewer as a yellow sensation. This was why color combinations like “greenish red” and “bluish yellow” couldn’t exist – each color term in the pair constituted component parts of sequential decompositions of the specialized color-sensing molecule. But it also explained why red, green, and blue lights appeared to mix to produce white: red and green mixed to produce yellow, which, when combined in correct proportion with blue, decomposed the color sensing molecule in its most primitive fashion – yielding only a sensation of lightness or darkness (figure 4.3). In this way, both the theories of Hering and of Helmholtz could be seen as special cases of a more comprehensive theory – not wrong, precisely, but blind to the complete range of human color experience.

Ladd-Franklin promoted her theory over the next thirty years in journals, public lectures, and classes at Johns Hopkins and Columbia College. Although the basic theory itself changed little she continually refined it and connected it with developments in other fields of vision science. Early on, she defined her four unitary colors as “sensations which are produced in their purity by, about, the wavelengths 576 mm, 505 mm, 470mm, and a colour a little less yellow than the red end of the



spectrum” – wavelengths different from, but in the same range as – Pillsbury and Bradley’s colors.<sup>129</sup> She triumphantly noted evidence by Spanish physician Ramon y Cajal that suggested that “cone” cells in the retina, responsible for sensations of color, were evolutionarily newer versions of “rod” cells in the retina, which gave rise to achromatic sensations of brightness.<sup>130</sup> Likewise, she approvingly cited an article by physiologist J.S. Burdon-Sanderson in *Nature* of 1893, which noted the presence of light-sensitive molecules even in microbes, suggesting that evidence of the most basic form of her light sensing molecule might still exist in primitive creatures (though Ladd-Franklin did not comment on Burdon Sanderson’s proposal that, unless psychologists were content to “admit a deferred epigenesis of mind, we must look for psychical manifestations even among the lowest animals,” since even the most rudimentary vision suggested a capacity for cognition; figure 4.4).<sup>131</sup>

But the most critical proof of the viability of her theory was never provided by advances in photochemistry, but in language. “We have the terms yellow green, reddish yellow, bluish green, greenish blue, blue-green, green-blue and blush red &c.,” she wrote, in an undated note, “But why not reddish green or greenish red? [...] You may say that language is an accident – and doesn’t decide things but not when the case is like this!<sup>132</sup> While psychophysicists like Rood and von Bezold considered the naming of colors to be incidental to understanding the ontology of color, for Ladd-Franklin, color names were an important – perhaps the most important –

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<sup>129</sup> Franklin, *Colour and Colour Theories*, on pg. 8.

<sup>130</sup> Franklin, *Colour and Colour Theories*, on pg. 48.

<sup>131</sup> J.S. Burdon-Sanderson, “Inaugural Address, British Association,” *Nature*, 1245:48, 14 Sept. 1893, pp. 464 – 472, on pg. 470.

<sup>132</sup> Christine Ladd-Franklin, Undated Notes, Box 50: Folder: MS re Color Theory & Color Terms, MS Coll Franklin, Christine Ladd-Franklin and Fabian Franklin Papers, Library of Rare Books and Special Collections, Columbia University.

piece of experimental data in revealing the underlying nature of the color sense. The existence of “yellow” as a unitary color was not, for Ladd-Franklin, an accident of language, but rather a fact to be reckoned with – red and green could be observed to mix to produce yellow; but that mixture was not called red-green. “Try to introduce the word,” Ladd-Franklin challenged a lecture audience. “[A]dd some visible green to red [i.e. mix red and green lights,] say the word + teach the child: this, my love, is called a red-green, or a green-red, whichever you like. He would hate you, for introducing a nasty trick into his science studies!”<sup>133</sup>

Similarly, the verbal reports made by individuals with monocular color blindness of the sensations they experienced through their color-blind eye compared with their normal eye, suggested to Ladd-Franklin that her theory was more viable than the three color theory of vision. Following Helmholtz’s trichromatic theory, Jeffries and Holmgren both believed that different forms of color blindness could be modeled by assuming that one of the three types of receptor cells in the retina of the observer lacked function. Thus they predicated their tests (2.6) on detecting cases of deficient red *or* green blindness (or much more rarely, blue blindness). But, Ladd-Franklin noted, when one actually paid attention to the sensations as *reported* by those who were color blind in one eye, it became apparent abundantly clear that it was not sensations of red *or* green that were nullified, but rather sensations of red *and* green; or sensations of yellow *and* blue. Color blindness tended affect color pairs, rather than individual colors. Indeed, this phenomenon had been suggested by

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<sup>133</sup> Christine Ladd-Franklin, Undated Notes, Box 50: Folder: MS re Color Theory & Color Terms, MS Coll Franklin, Christine Ladd-Franklin and Fabian Franklin Papers, Library of Rare Books and Special Collections, Columbia University.

physicians such as Charles Oliver, who felt that including yellow in his color blindness tests gave better results (see ch 2). But the dominance of Helmholtz's trichromatic theory – and the stricture against the verbal reporting of sensations in color blindness tests – induced the great majority of color blindness researchers to persist in modeling color blindness in terms of deficient red or green *cells*, and not in reports of paired nullification of red and green *sensations*. “There was absolutely no reason *except the theory* for affirming that the warm color of the defective person was either red or green;” wrote Ladd-Franklin, “all that was known was that it occupied the that portion of the spectrum which, for the normal person, is occupied by red, yellow *and* green.”<sup>134</sup> Thus rather than turning to the words used by color blind individuals to describe their sensations, physicians and physiologists who saw cases of red blindness and green blindness as proof of the success of Helmholtz's theory were guilty of “*infer[ing]* the sensations of the colour-blind from a theory which they have already adopted.”<sup>135</sup>

It was important to note, however, that color terms for Ladd-Franklin described states of mind, rather than objective physical facts. Light as denoted in terms of wavelength was not the same thing as the sensations that the observer experienced and described with terms like “red,” “yellow,” “green” and “blue.” This did not necessarily mean that the different wavelengths she had earlier named did not correspond to primary color sensations. But the fact that these wavelengths *could* be described by color terms did not therefore indicate that the meaning of red *was* “light with a wavelength of 576 mm.” Rather, as she put it “a single sensation,

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<sup>134</sup> Franklin, *Colour and Colour Theories*, on pg. 192.

<sup>135</sup> *Ibid.*

say, a grey-green-blue, can be excited by a thousand different combinations of electro-magnetic radiations – by a million, rather.”<sup>136</sup> As such, color terms were best understood as reflecting the inner state of the observer, rather than an objective psychophysical reaction to light of a particular wavelength striking the eye and inducing the partial decomposition of the light-sensing molecule. Indeed, in keeping with the doctrines of introspection, Ladd-Franklin proposed a bifurcated vocabulary for color, with terms like “erythogenic, xanthogenic, chlorogenic, cyanogenic and leucogenic” describing the objective quality of radiations that induced subjective sensations that observers described with the words “red,” “yellow,” “green,” “blue” and “white,” respectively.<sup>137</sup>

The difficulty with the introspective approach, as Ladd-Franklin’s bifurcated terminology suggested, was that words not only revealed mental structures, but also had the potential to create them. Scientists had to carefully police the words that sensations suggested, corrupted as they might be by ambiguities of meaning and signification. In a paper read at the American Psychological Association’s 1914 meeting entitled, “A Corrected Color Terminology,” Ladd-Franklin reproached her audience, writing, “the words orange and purple should never be admitted into scientific speech – non unitary colors should not be given unitary names. Just as there exist no unitary names for the yellow-greens and the blue-greens, so we should, in the other two series of color-blends, speak always of the red-blues and

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<sup>136</sup> *Ibid.*

<sup>137</sup> *Ibid.*

the red-yellows.”<sup>138</sup> The problem with giving non-unitary colors unitary names, for Ladd-Franklin, was that, in a sense, these names *made* colors into fundamental sensations that might not ordinarily be so. In an undated note to herself, Ladd-Franklin fretted about the nature of the color gray, writing that “[o]n account of its unitary name it is a far more unitary thing than it really is and far more unitary than it would be if [we] were always to call it (as we always call the blue-greens) a black-white.”<sup>139</sup> In this instance, gray was *made* a more “unitary thing” by its name than Ladd-Franklin supposed it be. That is, the name for the color short-circuited what she believed ought otherwise to be her introspective sense of the color. Further introspection, however, prompted Ladd-Franklin to reverse herself, writing later that “the ambiguous word *colour* should be used to include the colour grey (white).”<sup>140</sup> That is, gray was, in a sense, unitary, at least insofar as it was a special case of black and white.

On the other hand, by dint of their guilelessness, subjects like children could – at least in the opinion of some psychologists – provide better introspective evidence than adults.<sup>141</sup> In a review the 1897 edition of Joseph LeConte’s *Sight, an*

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<sup>138</sup> Christine Ladd-Franklin, “A Corrected Color Terminology,” *Psychological Bulletin*, 11:2, 15 Feb. 1914, pp. 52-53, on pg. 52.

<sup>139</sup> Undated Note, BOX 54: Folder: Color Terms, MS Coll Franklin, Christine Ladd-Franklin and Fabian Franklin Papers, Library of Rare Books and Special Collections, Columbia University

<sup>140</sup> Franklin, *Colour and Colour Theories*, on pg. 127.

<sup>141</sup> The question of whether children (and their evolutionary corollaries, “savages,” the “uncivilized,” and “primitive” people) were viable subjects for introspective psychology was a matter of some debate. Following James McKeen Cattell at Columbia, James Mark Baldwin, editor of the *Dictionary of Philosophy and Psychology*, answered in the affirmative. More doctrinaire introspectionists, such as Edward Titchener of Cornell, thought that introspection, strictly speaking, ought to be limited to subjects who had been trained to introspect – a view which sparked an ugly disagreement between Baldwin and Titchener (see Boring, *Experimental Psychology*, pg. 413 f 555). As a close correspondent of Baldwin’s – as well as an antagonist of Titchener’s (who refused to allow women into his elite club, “the Experimentalists”) – Ladd-Franklin seems to have cast her methodological lot with Cattell and Baldwin, rather than Titchener.

*Exposition of the Principles of Monocular and Binocular Vision*, Edward Scripture dismissed the theory of four unitary colors that LeConte promoted (citing Ladd-Franklin), reflecting that only those who consciously learned to see “violet” as a combination of “red” and “blue” would mentally decompose the color into its constituent parts – just as to children, “orange is as much a primary color as red is.”<sup>142</sup> In defense of her theory, Ladd-Franklin confronted Scripture with introspective evidence of her own – namely, an experience related by her own daughter at an age when she didn’t know the word for purple. When one day viewing a “large a brilliantly lighted up surface of that color,” the girl nevertheless gave it her full attention and, in Ladd-Franklin’s recollection, “said, in what we used to call her hypothetical tone of voice: ‘B’u – Wed! – Wed! – B’u!’” which Ladd-Franklin interpreted to mean “‘perhaps I should call this blue! – Perhaps I should call it red!’”<sup>143</sup> To Ladd-Franklin, the conclusion was clear: if purple had been a unitary color, like yellow, her daughter would not have been able disentangle its chromatic elements so easily. She would instead have struggled to find a word to describe a sensation that was unlike any other in her mind. The fact that her daughter had immediately tried to associate purple with its two component colors therefore spoke both to the non-unitary nature of purple, as well as to the fact of unitary red and blue. Thus, due to their lack of sophistication or artifice, children – both Scripture and Ladd-Franklin agreed – could be trusted to reveal the true essence of color through the reporting of their sensations, although sophisticated

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<sup>142</sup> Edward Scripture, Review of *Sight, an Exposition of the Principles of Monocular and Binocular Vision* by Joseph LeConte, *Psychological Review*, 4:5, Sept. 1897, pp. 543-545, on pg. 545.

<sup>143</sup> Ladd-Franklin, “Color-Introspection on the Part of the Eskimo,” on pg. 398.

observers might disagree on the interpretation of their reports. To complete the experiment, Ladd-Franklin sardonically suggested that it would be necessary to find a child “brought up in an aesthetic atmosphere of nothing but blue-greens and green-yellows” in order to see whether, when presented with a swatch of pure green, the child recognized it as simply green, or as one of the hybrid colors that she had known.<sup>144</sup>

Ladd-Franklin’s concern with the precision of color names was not, however, the same as that of Ridgeway, or Bradley and Pillsbury. That is, on the one hand, she scoffed at Hering’s followers who spoke of basic colors as “hering red” or “hering green,” remarking that they might as well speak of “hering crimson” and “hering peacock,” so unscientific was their outlook.<sup>145</sup> In this instance, “crimson” and “peacock” stood, for Ladd-Franklin, as the very apotheosis of unscientific color terminology. At the same time, commenting on the curious fact that non-unitary colors like “blue green” and “yellow green” were not named for similarly-colored objects – unlike “orange” and “violet,” which bore the “plain names of the flower and the fruit which stand for them” – Ladd-Franklin recommended “peacock” and “olive” respectively as terms that would fill the role. Though she admitted that olive – at least as it signified the fruit of the olive tree – was not exactly a yellow-green, Ladd-Franklin shrugged, “there is no harm in changing its signification a little for scientific purposes.”<sup>146</sup>

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<sup>144</sup> Ladd-Franklin, “Color-Introspection on the Part of the Eskimo,” on pg. 398.

<sup>145</sup> Christine Ladd-Franklin, Undated Notes, Box 50: Folder: Lecture notes, MS Coll Franklin, Christine Ladd-Franklin and Fabian Franklin Papers, Library of Rare Books and Special Collections, Columbia University.

<sup>146</sup> Ladd-Franklin, *Colour and Colour Theories*, on pg. 36.

Moreover, in her one desultory attempt to create a “color terminology” of her own, Ladd-Franklin appeared to be more interested in rehashing the structure of her development theory than in providing a comprehensive notation of sensations. A single page of sketchy, undated notes calls for a color terminology system based on “six visual sensations, or colour sensations”: “one non-light sensation, or achroma, black” and “five light sensations” divided into one “achromatic light-sensation → achroma white” and “four chromatic light sensations” or “unitary colors”: yellow, blue, red and green.<sup>147</sup> From these basic categories, non-unitary colors could be notated as combinations of unitary colors. Indeed, for quaternary color blends, “whenever the intensity of a colour (or color compound) becomes lost, black “jump[s] in. Thus,” she concluded, “the colour of the bayberry is black-white-blue-green, or a gray-green-blue.”<sup>148</sup> Unlike the color nomenclatures of Ridgway, or Bradley and Pillsbury, Ladd-Franklin was more interested in discerning the *fact* of the component parts of complex colors rather than solidifying the exact proportions of components of each color, because the fact of component colors yielded truth about the facts of color vision, which in turn revealed the mental life of human beings.

Ladd-Franklin’s theory was respected by her peers, but not remembered. It never made the lasting impact that might have been expected from the serious

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<sup>147</sup> Christine Ladd-Franklin, Undated Notes, Box 50: Folder: Color Terminology, MS Coll Franklin, Christine Ladd-Franklin and Fabian Franklin Papers, Library of Rare Books and Special Collections, Columbia University.

<sup>148</sup> Christine Ladd-Franklin, Undated Notes, Box 50: Folder: Color Terminology, MS Coll Franklin, Christine Ladd-Franklin and Fabian Franklin Papers, Library of Rare Books and Special Collections, Columbia University.



interest given it on the part of influential physiologists and psychologists as well as her own constant advocacy of her ideas. Helmholtz himself responded favorably to her presentation of 1892, murmuring, “*ach [...] Frau Franklin – die versteht die Sache!*” (i.e. Mrs. Franklin understands the matter [of color]), while the influential physiologist William Henry Howell wrote in his 1901 *American Text-Book of Physiology* that Ladd-Franklin’s theory was “in some respects more in harmony with recent observations in the physiology of vision” than any other.<sup>149</sup> By 1922, Deane B. Judd could write in the *Journal of the Optical Society of America* that her success in uniting Hering’s and Helmholtz’s models of color vision “is probably the basis for the increasingly wide acceptance which the Ladd-Franklin genetic theory of color is now enjoying.”<sup>150</sup> And as late as 1940 – ten years after her death, *Optometric Weekly* listed Ladd-Franklin’s theory alongside those of “Helmholtz [and] Herring [sic]” as being among “familiar color theories” that required greater explanation.<sup>151</sup> For all of this support, however, as historian Laurel Furumoto points out, Ladd-Franklin labored without access to the resources and connections that allowed her male peers to train students and engage fully-fledged research programs. As a married woman – even a married woman with an extensive list of publications, connections with powerful scientists, and deep respect within the discipline – Ladd-Franklin was denied professorships in psychology departments of Johns Hopkins or Columbia, where she had followed her husband. Forced instead to teach single classes, often

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<sup>149</sup> *An American Text-Book of Physiology*, ed. William Henry Howell (Philadelphia: W.B. Saunders & Company, 1901) on pg. 337.

<sup>150</sup> Deane B. Judd, Review of *Colour and Colour Theories* by Christine Ladd-Franklin, *Journal of the Optical Society of America*, August 1929, pp. 103-105, on pg. 104.

<sup>151</sup> “News,” *Optometric Weekly*, 31: 5, 1940, on pg. 804.

for free, Ladd-Franklin was able to promulgate her work only as a sideline to the main work of burgeoning psychology departments. Moreover, Ladd-Franklin had limited access to the scientific societies that were fertile grounds for collaboration and mutual support. “The Experimentalists,” for instance, an elite club founded in 1892 by E.B. Titchener for connecting those psychologists “who had arrived” with promising aspirants, strictly barred women from attending meetings – an attitude which Ladd-Franklin excoriated as “[s]o unconscientious, so immoral, – worse than that – so unscientific!”<sup>152</sup> The club eventually allowed women in 1929 – two years after Titchener’s death, and a year before Ladd-Franklin’s. The inability to train students, cultivate junior faculty and inaugurate research programs left Ladd-Franklin without the committed disciples (such as Müller was to Hering, or König to Helmholtz) necessary to reinforce and sustain her work after her death.

By the time of her death, Ladd-Franklin’s color work had foundered on the shoals of disciplinary divides and shifts in research style. Reviewing Ladd-Franklin’s 1929 book, *Colour and Colour Theories* – a compendium of Ladd-Franklin’s papers, published the year before her death – Cornell psychologist Elise Murray wrote that, in spite of Ladd-Franklin’s valuable suggestions about the evolutionary roots of color vision, and her insistence on precise discrimination between objective stimulus and subjective sensations, the

“laboratory psychologist is compelled to adjudge the postulates of Ladd-Franklin as little satisfactory as the discarded ones of Helmholtz. The explanations of color-blindness discoverable in these pages are sketchy,

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<sup>152</sup> Quoted in Furumoto, “Joining Separate Spheres,” on pg. 97.

involved, and little helpful. The psychological premises themselves on which the older theories are attacked and the superiority of the genetic hypothesis advanced are less compelling than in the nineties. Reliance upon the 'immediate deliverances of consciousness' in the selection of color 'primaries' fell away in the early nineteen-hundreds.<sup>153</sup>

Ladd-Franklin herself in 1927 lamented the slackening of interest in her work, and in color in general, particularly among physicists, who she still considered to be viable audience, writing, "[a]t this time, when one daily expects exciting news from Schrödinger and Heisenberg, it is rather difficult to secure attention for such matters as color theories" – ironic, if only for the fact that Schrödinger had, in fact, published his own theories of color measurement in the 1920s.<sup>154</sup> Beginning in the 1950s, "zone" theories of color – in which color perception began to be seen as a combination of physical and mental processes – began to gain precedence as viable explanations of human color perception. As psychologist Gerald S. Wasserman has argued, although Ladd-Franklin's was arguably the first serious attempt to produce a zone theory of color, because she "expressed her ideas in terms of a hypothetical photochemistry which has not stood the test of time; critics focused on the auxiliary photochemical notions and largely ignored the genuine contribution of her theory" – that is, her attempt to think of color terms as descriptions of mental processes

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<sup>153</sup> Elsie Murray Review of *Colour and Colour Theories* by Christine Ladd-Franklin, *The American Journal of Psychology*, 41: 4, Oct. 1929, pp. 653-656.

<sup>154</sup> Christine Ladd-Franklin, "Mischance in the Science of Color," Box 50: Folder: Mischance in the Science of Color, MS Coll Franklin, Christine Ladd-Franklin and Fabian Franklin Papers, Library of Rare Books and Special Collections, Columbia University For Schrödinger's theories see Erwin Schrödinger, "Theorie der Pigmente von größter Leuchtkraft," *Annalen der Physik*, 4:62, 1920, 603-622; Erwin Schrödinger, "Grundlinien einer Theorie der Farbenmetrik im Tagessehen," *Annalen der Physik*, (4), 63, 1920, 397-426; 427-456; 481-520, and Erwin Schrödinger, "Farbenmetrik," *Zeitschrift für Physik*, 1, 1920, 459-466.

independent from descriptions of objective physical stimulus.<sup>155</sup>

### Conclusion

In a certain sense, the story of attempts to attach definite names to color sensations according to the standards of science is a story of the failure of scientific reason.

Ladd-Franklin's efforts to define basic color sensations were rejected – or at least, subsumed into later theories of perception.<sup>156</sup> Bradley's system of color naming, as represented most closely in his system of educational colored papers was never less than a drag on the company's finances, and Bradley's successor discontinued them after Bradley died. Of all of the attempts at thinking about color names here described, Ridgway's – ridiculed by Hallock and Gordon as conflating objects with sensations; laughed at by Ladd-Franklin for being an affront to scientific reason (“if he only had the color triangle before him!!!” she jeered while reading his book) – was the most successful, at least in terms of common use. Ridgway persisted in using vague, colloquial nomenclatures for color, insisting in 1912 that “an expression of opinion [...] from many naturalists and others,” indicated a strong preference for evocative color names over more abstract conventions.<sup>157</sup> And while Daniel Lewis, senior curator of science and technology at the Huntington museum, admitted that Ridgway used “very colorful language” in naming the colors in his 1912 edition (a curious recursion calling attention to the slipperiness of sensory

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<sup>155</sup> Gerald Wasserman, *Color Vision: an Historical introduction* (New York: Wiley, 1978) on pg. 113.

<sup>156</sup> See, e.g. Elise Murray, “Color Problems: The Divergent Outlook of Physicist and Psychologist,” *The American Journal of Psychology*, 42: 1, Jan. 1930, pp. 117-127; and Dorothy Katzin and E. Murray, “Instability in Color-Naming in Normal and Anomalous Observers,” *The American Journal of Psychology*, 46: 4, Oct. 1934, pp. 611-620.

<sup>157</sup> Ridgway, *Color Standards*, on pp. 10-11.

terms), Lewis went on to point out that, in 2008, “[e]veryone from stamp collectors to naturalists to chemists refers to ‘Ridgway colors’ to identify specific shades.”<sup>158</sup>

Attempts to name colors according to the standards of science neither reassured Americans of their own modernity vis-à-vis “semi-civilized” peoples, nor did they lead Americans to place a greater stock in the veracity of their own basic sensations, nor, perhaps needless to say, did everyday people begin to speak with greater clarity about color names – though a whiff of the theme occasionally seeped into popular reporting. A *Los Angeles Times* style piece from 1929, for instance, began with the promise that “[a]lthough every manufacturer, every weave of materials, and one might say every retail establishment has a range of color names for its chosen product, still there are certain colors [...] which may be recognized by their names, descriptive of the actual color.” The article then went on to list under “the browns” “seal brown, also known as Afrique or merisand; witch brown, also known as autumn; chocolate, Philippine, capuchine brown, also known as peach stone; burnt siennt [sic], patio brown, also known as Barcelona; russet, red head. In a tone between brown and red,” the article notes, “there is brandywine.” The same went for “blue” (“navy or marine, independence, imperial, monet”); for “green,” (“English green, bottle green, cucumber, new grass”); “yellow” (“nasturtium yellow, capucine gold, also known as curry; egg yellow, turmeric, mais,” and so forth until the article arrived at “black and white, ever present in feminine dress.”<sup>159</sup> Thus, in a formal sense, anyway, the article made an attempt to simplify its color reporting in a

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<sup>158</sup> Traude Gomez-Rhine, “In Living Color: A Conversation with the Dibner Senior Curator of the History of Science and Technology,” *Huntington Frontiers*, Fall/Winter 2008, pp. 6-10, on pg. 7.

<sup>159</sup> “Brown Favorite Color,” *Los Angeles Times*, 11 Sept. 1929, pg. C12.

manner not unlike Ridgway, filing its evocative color terms under simple, abstract headings, before concluding with black and white – Berlin and Kay’s two most basic colors.

If anything, those who attempted to establish scientific nomenclatures between 1886 and 1929 induced their successors to throw in the towel. As Aloys J. Maerz and Morris Rea Paul, authors of the 1930 *Dictionary of Color*, commented in the preface to their work, “[i]t is true that our present language of color is, to a certain extent, composed of words that are somewhat meaningless in themselves as color terms. This refers to such words as ‘folly,’ ‘Westminster,’ and ‘elephant’s breath’; they are lacking entirely in descriptive color value, *yet their continued use earns them a place among the accepted color terms that custom has decreed should compose our vocabulary.*”<sup>160</sup> Rather than taking science (physics, physiology, psychology) as their guiding principle – the warrant that would overpower the arbitrariness of individual perception; overturn the vagaries of commerce, decoration and artifice; and elevate the primitive underpinnings of civilized sensation – Maerz and Paul turned instead to “custom” to justify their selection of color terms. Custom, in this case, wore down the precision edge of science.

But if they were failures of scientific reasoning, attempts to define color words scientifically were also exemplars of scientific imagination. They were fantasies of the possibilities of science; fantasies of how science could change everyday life on a fundamental level. Psychophysical studies and color blindness research had revealed vision as disturbingly unreliable – part of a sensorium

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<sup>160</sup> A. Maerz and M. Rea Paul, *A Dictionary of Color* (New York: McGraw-Hill Book Company, 1930) on pg. v. Italics added.

unmoored by either a divine presence or a reliably shared sense of what things were like. The flood of ostensibly new, ever-changing colors in commerce, advertising and art – unable to be precisely named, or even, apparently, rationally described – had confirmed the worst fears of those who saw in modern society dissolution and drift. Against this drift, the mastery of concrete, basic terms was a salve. The idea of basic, standardized color vocabularies were in this sense the flip-side of Sadikichi Hartmann’s fantasy about colors that had never before been seen, that needed new names like “ultra red” and “ultra violet.” They held the hope that there was, in fact, order to be found within the ostensible chaos, and that modern society was, in fact, superior to its alternatives. This fantasy, moreover, did not evaporate, even if attempts at colloquial nomenclature did, but simply shifted its discipline. It is precisely this notion of a rationally grounded, semantically accessible color sensation that survives, for instance, in the “basic color terms” of Berlin and Kay.

# 5

## Re-Inventing Color The Munsell Color System

### Introduction

Not all attempts at applying scientific certainty to color naming and ordering systems were as ill fated as those of Ridgway, Bradley and Pillsbury, and Ladd-Franklin. In 1905, Albert Henry Munsell, a professor of studio art and anatomy at the Massachusetts Normal Art School published *A Color Notation* – a short book describing his system for alphanumerically ordering and notating “the indefinite and varying colors of natural objects.”<sup>1</sup> As with his predecessors, Munsell saw his system as an antidote to the “incongruous, irrational and often ludicrous” color names of nineteenth century commerce.<sup>2</sup> And like his predecessors, Munsell was concerned that his system rest upon a bedrock foundation of science, based “not whim of an individual, but upon physical measurements made possible by special color apparatus.”<sup>3</sup>

Unlike his predecessors, however, more than century after he first proposed his eponymous scheme, the Munsell color system is not only still in use, but has

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<sup>1</sup> Albert Henry Munsell, *A Color Notation*, Boston: George Ellis and Co., 1905, on pg. 10.

<sup>2</sup> *Ibid.* on pg. 75.

<sup>3</sup> *Ibid.* on pg. 9.



distinguished itself as one of the more enduring and ubiquitous ordering and notation schemes in color work. At present, Munsell's system is used in a staggering array of scientific and industrial applications from forensic pathology, to ophthalmological testing, to "evaluating the colors of Frozen French Fried Potatoes."<sup>4</sup> In the 1960s and 1970s, anthropologists and linguists – like Berlin and Kay – used arrays of Munsell colors to investigate the connections between color naming and cognition among the speakers of different languages. In the 1980s, the Apple computer company used Munsell's system to ensure that the grey housings of their computers all fell within tolerable limits of grayness; while during the same period the Hershey Chocolate company used the Munsell System to ensure that the orange wrappers of its Reese's Peanut Butter cups were optimally orange.<sup>5</sup> In the past decade, soil scientists in Brazil and computer scientists in Massachusetts alike have turned to Munsell's system as a reliable standard, and the list goes on.<sup>6</sup> Indeed, so ubiquitous is Munsell's system that it can be made to serve as a ribald synecdoche for the fecundity and vitality of the field of color science on a whole. In a 2010 conference talk entitled "Color Naming: Color Scientists do it Between Munsell

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<sup>4</sup> See, e.g. "Instructions for Using USDA Color Standards for Frozen French Fried Potatoes," United States Department of Agriculture, August 1988, in A.H. Munsell Papers, Massachusetts College of Art Library and Archives, Massachusetts College of Art.

<sup>5</sup> "Apple Platinum," 1986, in A.H. Munsell Papers, Massachusetts College of Art Library and Archives, Massachusetts College of Art; and "Film Color Tolerance Set: Reese's Orange," October 1988, in A.H. Munsell Papers, Massachusetts College of Art Library and Archives, Massachusetts College of Art.

<sup>6</sup> On soil science see Bruno Latour, *Pandora's Hope: Essays on the Reality of Science Studies*, (Cambridge: Cambridge University Press, 1999) pp. 58-59; for uses in computing see <http://people.csail.mit.edu/jaffer/Color/Dictionaries> last accessed 7/2010; for other uses consider vision testing: A. Kurtenback, C. Erb, M. Adler, B. Born, "Colour Vision in Diabetics Tested by the Farnsworth-Munsell 28 Hue Desaturated Test," *Color Research and Application, Supplement*, Vol. 26, 2001, pp. S292-S296; on archeology: Andrew Jones and Gavin MacGregor, eds *Colouring the Past: the Significance of Colour in Archeological Research* (New York: Oxford Press, 2002); on analyzing the color of water (that is, literally "water color"): Robert J. Davies, David G. Smith, David J. Speed, and John W. Nagels, "Matching Natural Water Colors to Munsell Standards," *Journal of the American Water Resource Association*, 33:6, Dec 1997, pp. 1351- 1361.

Sheets of Color” two scientists from Hewlett Packard Corporation argued that simply because of its common use within science and industry, the Munsell system provided the only reliable standard of color with which to adjudicate human color perception.<sup>7</sup> If not quite a double entendre (those who use Munsell color charts tend to work “with” the charts rather than “between” them, thus sharply narrowing the possible meanings of the title) it nevertheless serves as a reminder that, for a great many people and purposes, Munsell’s early twentieth century notion of a sequential order to color sensations *is* color.

On the one hand, then, the closeness with which Munsell’s system meshes with present-day modes of production and scientific inquiry can make its development seem almost inevitable – a simple matter of scientific progress marching inexorably towards ever-more-useful definitions of the natural world. Certainly this was Munsell’s view. As he wrote in 1909, “it is not I who have ‘managed’ the color circle of balanced pigment hues, but [rather] the character of these pigment measures and the structure of our color sense have decided their kind and degree.” The matter, concluded Munsell, is “over our heads.”<sup>8</sup> Subsequent historical analyses of Munsell’s system have tended to hew to Munsell’s account of his system. For instance, in their short history of the Munsell scheme, Edward R. Landa and Mark D. Fairchild write that “[t]he visual uniformity of the Munsell system has been one of the most significant attributes in making it one of the most

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<sup>7</sup> Giordano B Beretta and Nathan M. Moroney, “Color Naming: Color Scientists do it Between Munsell Sheets of Color,” *Color Imaging XV: Displaying, Hardcopy, Processing, and Applications*, 17 - 21 January 2010, San Jose, California.

<sup>8</sup> Diary of Albert H. Munsell, Sept 20, 1909, Typed copy from handwritten original; original in possession of Hagley Library, University of Delaware.

important and influential color specifications of the last century” – reinforcing that it is the naturalness of Munsell’s system that makes it an effective tool.<sup>9</sup> Indeed, its use can seem almost fated: as Jan Koenderink, a color researcher at the University of Delft put it in a recent monograph covering two centuries of color science, the Munsell color system became the “de facto” standard for color throughout the twentieth century and into the twenty-first “more or less by way of historical accident” – effectively placing the complex business of negotiating formal representations of color squarely on the agency of history.<sup>10</sup>

On the other hand, as a number of social scientists have pointed out, such accounts tend to elide the cultural and material work required – both by Munsell himself and by subsequent users of his system – to produce, modify and accept the Munsell system as a natural accounting of color. Writing about the use of the Munsell system in archeology, for instance, anthropologist Charles Goodwin notes that “the definitiveness provided by [Munsell’s] coding scheme typically erases from subsequent documentation the cognitive and perceptual uncertainties” involved with matching colors on dig sites to colors in Munsell’s system of color charts.<sup>11</sup> In a similar way, philosopher Arnold Henselmans cautions that psycholinguistic studies of color perception which use arrays of Munsell chips say more about subjects’ regard for the arrays than about their perception of color – a condition he refers to

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<sup>9</sup> Edward R Landa and Mark D Fairchild, “Charting Color from the Eye of the Beholder,” *American Scientist*, Sep/Oct 2005. 93:5; pp. 436 – 444, on pg. 443.

<sup>10</sup> Jan J. Koenderink, *Color for the Sciences* (Cambridge: MIT Press, 2010) on pg. 34.

<sup>11</sup> Charles Goodwin, “Professional Vision,” *American Anthropologist*, 96:3, 1994, pp. 606-633, on pg. 609.

as the “Munsell constraint.”<sup>12</sup> And in a well known response to Berlin and Kay’s color work, anthropologist Marshall Sahlins remarked in 1976 that “a semiotic theory of color universals must take for ‘significance’ exactly what colors do mean in human societies. They do not mean Munsell chips.”<sup>13</sup> That is, for Sahlins, the “meaning” of color is necessarily tied with the material, cultural and social work of color, as employed by specific groups of people at specific times and places.

This chapter elucidates the “significance” of Munsell color chips for one such specific group: the turn of the century Americans who designed, manufactured, promoted, and argued over Munsell’s system. Though this group includes not least of all Munsell himself, Munsell neither worked in isolation, nor was the objective avatar of nature, chopping the spectrum at its joints. Rather, as he endeavored to work through the epistemological and ontological underpinnings of his systematic, scientific notation, he relied on an extensive network of colleagues, collaborators and opponents – physicists, psychologists, educators and industrialists, among others. As he conceived of, fabricated, and marketed his novel system of color arrangement, he had at every moment to navigate the complex and multivalent meanings of color for turn of the century American society. As such, Munsell crafted a system that was both rigidly formal and epistemologically flexible – a system perfectly suited to juggle not simply the “natural” apprehension of color, but the formal, scientific and cultural meanings of color for turn of the century Americans.

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<sup>12</sup> Arnold Henselmans, “The Munsell Constraint,” in *Theories, Technologies, Instrumentalities of Color: Anthropological and Historical Perspectives*, ed. Barbara Saunders and Jaap van Brakel (Lanham, MD: University Press of America, 2002) pp. 37-53. Barbara Saunders and Jaaps van Brakel more generally consider color science in twenty-first century industrial societies in their “The Trajectory of Color,” *Perspectives on Science*, 10:3, 2002, 302-355; William Leach touches briefly on Munsell as a common form of color categorization in *Land of Desire* (New York: Vintage Press, 1981) pg. 50.

<sup>13</sup> Marshall Sahlins, “Colors and Cultures,” in *Culture in Practice* (New York: Zone, 2000) pp. 139-163.

The simplicity of Munsell's system was one of its strengths. All colors, as he wrote in his 1905 *A Color Notation*, could be thought of as consisting of three fundamental components: *hue* – similar to the wavelength of the ether waves of which light was comprised; *value* – similar to the lightness or radiant flux of the light; and *chroma*, or the purity of the hue relative to its value and spectral compliments. By arranging these properties in three dimensions, with spectral colors placed at regular intervals along the circumference of a circle representing hue; a perpendicular scale of grays originating at the center of the circular spectrum representing value; and the distance from the origin of the value scale outwards towards the edge of the hue ring indicating chroma, Munsell produced a “color solid” – a shape that represented the sum total of all possible color sensations capable of being experienced by human beings. Indeed, the color solid was so designed as to accommodate “still stronger colors” than had been experienced by human beings, “should science discover them.”<sup>14</sup> Because Munsell had calibrated his system so that each degree of change in color sensation was located at point equidistant from its neighbor, every point on the color solid could be indicated by a coordinate system, and these coordinates could be used to precisely define particular colors. A color located in the middle of the green arc of the spectral plane, roughly midway between black and white in terms of value, and with somewhat more than a 50% saturation (or chroma) might be notated as 5G6/5, for example, instead of the ambiguous term like “grass green.”

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<sup>14</sup> Albert H. Munsell, “Color and an Eye to Discern it” (Boston: the Author, 1912) on pg. 2.

Munsell's was not the first attempt to render either a color sphere or a three-dimensional color solid. In 1611, Swedish mathematician Aron Sigfrid Forsius seems to have devised a spherical color system with white and black at either pole, and red, yellow, blue, and green arranged in an equatorial band – though the exact nature of Forsius's system is subject to some debate among art historians and historians of science.<sup>15</sup> More recently, and more definitely, Phillip Otto Runge, a German romantic painter, devised a color sphere in 1802 which featured black and white poles mediating red, blue, and yellow primary “elements” – a system not at all dissimilar to Munsell's.<sup>16</sup> Austrian physiologist Ernst Brücke similarly contrived a spherical color solid in 1866 that had black and white poles, and alternately four to eight principle spectral colors.<sup>17</sup> Wilhelm Wundt likewise produced a color sphere in

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<sup>15</sup> Forsius's diagrams depict a circle with a central axis running from top to bottom and featuring two symmetrical bowed arcs also extending from the top of the circle to the bottom; a basketball viewed from the side comes to mind as a reasonable visual synonym. Forsius marked the top of the circle “white” and the bottom “black” and indicated positions of colors both within the body of the circle and along its edges. Art historian John Gage follows color scientists R.L. Feller and A. Stenius in interpreting the diagram as a side elevation view of a globe with longitudinal divisions. Color scientist and historian Rolf G. Kuehni, however, objects on the grounds that, firstly, Forsius's diagram does not display the sophistication of an individual who would surely have known how to draw a transparent sphere (rather than a flattened side view), and secondly, that Forsius did not mention a spherical scheme to his color diagram in the text accompanying his drawings. Kuehni concludes that it is erroneous to think of Forsius's diagram as a three dimensional color space. In a footnote, it must be pointed out Gage splits the difference, suggesting that, while spherical, Forsius's color space was not three dimensional in the same sense as his successors in the nineteenth century. (See John Gage, *Colour and Culture: Practice and Meaning from Antiquity to Abstraction* (London: Thames and Hudson, 1993) pp. 46-47; and Gage's original source, R.L. Feller, and A. Stenius, “On the color space of Sigfrid Forsius, 1611,” *Color Engineering* 8, 1970, 51-58. Rolf G. Kuehni and Andreas Schwartz provide a dissenting view in *Color Ordered: a Survey of Color Order Systems from Antiquity to the Present* (New York: Oxford University Press, 2008) on pp. 45-46).

<sup>16</sup> Rolf G. Kuehni provides a brief summary of a number of three dimensional color systems, including Runge's, that predated Munsell's in his article, “The Early Development of the Munsell System,” *Color Research and Application*, 27:1, Feb. 2002, pp. 20-27, on pp. 20-21. See also, more generally, Kuehni and Schwartz, *Color Ordered*, on pp. 45-46; K. T. A. Halbertsma likewise provides a number of examples of three dimensional color systems in *A History of the Theory of Colour* (Amsterdam: Swets & Zeilinger, 1949).

<sup>17</sup> See Kuehni, “Early Development of the Munsell System;” also Ernst Brücke, *Die Physiologie der Farben für die Zwecke der Kunstgewerbe* (Leipzig, Germany: Hirzel, 1866) on pp. 68-74.

1874 based on eight equatorial colors, but subsequently switched to a color cone.<sup>18</sup> Chevreul, meanwhile, imagined a color hemisphere in 1838, with white at the middle of the circular base, black at the edges, and the spectral colors in between; the dome of the hemisphere contained different mixtures of the base colors.<sup>19</sup> Still others had tried different shapes. In 1772 German mathematician Johann Heinrich Lambert published his *Farbenpyramide* – a document describing a seven-layered pyramid with red, yellow and blue at its base vertices, and white at its apex.<sup>20</sup> In 1847, Austrian mathematician Christian Doppler modeled color space as a “spherical octant” – a sort of tri-cornered parachute shape.<sup>21</sup> Ewald Hering’s theory was not unrepresented among three dimensional models, as Alois Höfler demonstrated in his 1897 double-pyramid, which placed Hering’s white and black opponent pair at either apex of the pyramid, and his blue/yellow and red/ green opponent pairs at the four central corners.<sup>22</sup> And, while his was not a color system, it should likewise be mentioned that, seemingly alone among schemes to order the senses, in 1915, German psychologist Hans Henning proposed a three-dimensional smell-pyramid – an attempt at ordering the olfactory based on the long-standing psychophysical tradition of modeling color in three dimensional space.<sup>23</sup>

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<sup>18</sup> See Kuheni, “Early Development of the Munsell System,” on pg. 21.

<sup>19</sup> In addition to Kuheni, see Ethel Heila, “The Chevreul Color System,” *Color Research and Application*, 16:3, Jun. 1991, pages 198–201; Françoise Viénot, Alain Chiron, “Michel–Eugène Chevreul and His Colour Classification System,” *Color Research and Application*, Supplement Vol. 26, 2001, pp. S20–S24; also M. Chevreul, *The Principles of Harmony and Contrast of Colors* (New York: Van Nostrand Reinhold, 1981:1839).

<sup>20</sup> See Kuheni, “Early Development of the Munsell System,” on pg. 21.

<sup>21</sup> *Ibid.*

<sup>22</sup> *Ibid.*

<sup>23</sup> See. E.g. Review: *Der Geruch*, by Hans Henning, *American Journal of Psychology*, Vol. 32, 1921, pp. 290–295.

But of these attempts, Munsell's was the first to merge the theoretical, physiological, practical and moral aspects of three dimensional color arrangement. As a scientific formalism, Munsell's color solid was – to borrow a phrase from historian of science Ursula Klein – semiotically “compact,” or “dense;” that is, it had the ability to “conve[y] a plurality of information simultaneously.”<sup>24</sup> It provided, for one thing, a one-to-one representation of color order; the colors on the sphere represented themselves (i.e. they were not spectral colors or colored objects; they were simply colors). At the same time, Munsell's color solid represented the order underlying color sensations – based on a mechanical metaphor for the physical and physiological aspects of color. And finally, the color solid presented a lesson about aesthetic balance – about what color *ought* to be like, as well as what it *is*. This sort of protean ability shift significance, Klein explains, is a useful quality for formal systems to have. Just as Klein explains that the Berzelian diagrams that used by nineteenth century chemists were successful because their “different layers of reference and meaning [...] did not commit chemist to elaborate, foundational theories,” so, too did the multivalent nature of Munsell's color scheme allow him and his peers to continually reshape and rethink his approach to the fundamental nature of color.<sup>25</sup> In its ability to provide this latitude of thought, Munsell's system was ideally suited to address ambiguous questions of the physiological and moral underpinnings of aesthetics in turn of the century American society.

Far from being a stable property of lived experience, for Munsell and his

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<sup>24</sup> Ursula Klein, *Experiments, Models, Paper Tools: Cultures of Organic Chemistry in the Nineteenth Century* (Stanford, Stanford University Press, 2003).

on pg. 12.

<sup>25</sup> *Ibid.* on pg. 20.



peers, the “true” experience of color was a rare, precarious and fluid phenomenon. As Anson Cross, one of Munsell’s like-minded colleagues at the MNAS put it, the “average man” was “blind” to color – not in terms of “actual perception,” but in the ability to make sense of the stimulus bombarding him from without. The only cure for this condition, Cross suggested, was a careful extraction of the cognitive weeds that stood between sense and experience – a return, in a sense, to the “innocent eye” described by English art critic John Ruskin.<sup>26</sup> For Munsell, the eye was not so much innocent, as hopelessly naïve – “the eye is the most easily ‘fooled’ of all our senses,” he remarked, “Color impressions are so fleeting [...] that one must have a fixed point of departure to determine his bearings in the sea of color.” Nor were concerns with the malleability of the senses limited to educators. Author Theodore Dreiser wrote breathlessly of his discovery, through the works of psychologist Elmer Gates, that, far from being limited as given, “the senses can be educated to a much higher degree of accuracy” – an exciting development not least of all “[b]ecause the senses are the instruments of observation by which we get images of objects, and the investigator who can see color-differences and hear sound differences and feel touch-differences more minutely than another will be able to detect physical differences in objects not before detected and so increase the sum of human knowledge[...]<sup>27</sup> Gates, for his part, described the experimental results of a period he spent “giving certain animals an extraordinary and excessive training in one mental faculty.” “During five or six months, for five or six hours each day,” he wrote, “I trained dogs in discriminating

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<sup>26</sup> Anson Cross, *Color Study: A Manual for Teachers and Students* (Boston: Ginn and Co., 1896).

<sup>27</sup> Theodore Dreiser, “The Training of the Senses.” unpublished manuscript, Theodore Dreiser Collection, Folder 12433, Annenberg Rare Book & Manuscript Library, University of Pennsylvania.

colors. The result was that upon examining the occipital areas of their brains I found a far greater number of brain-cells than any animal of like breed ever possessed.”<sup>28</sup>

Theories and practices of color perception, then, sat at the intersection of theories and practices of the mind and of the body – of thinking and sensing, building and being. As a brochure for the Munsell system (circa 1910) put it, “the Great Underlying Principle of the Munsell System is, [sic] that the human race is born with eyes, which, when normal, see all the color of the universe, hence any training in color one receives must necessarily be *mental*.”<sup>29</sup> By correctly interpreting the relationship between cognition and craft, Munsell and a great many of his peers in art education felt that it would be possible to produce a new generation of Americans: morally, perceptually, aesthetically, and in some cases physically better suited to industrial American modernity than their forebears. At the same time, the converse was also true – incorrectly understanding the relationships between cognition, perception, and physical being could lead to lasting ill effects – not simply a poor understanding of art, but mental and perhaps even physical trauma. As such, Munsell’s system is best understood not simply as an enduring catalog of visual phenomenon, but as a record of the anxieties that drew together questions of physiology, language, art and society in late nineteenth and early twentieth century America.

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<sup>28</sup> Elmer Gates, *The Relations and Development of the Mind and Brain* (New York: Theosophical Society Publishing Department, 1904) on pg. 9.

<sup>29</sup> Wadsworth and Howland co., “The Munsell Color System,” n.d. (1910?), Denman Waldo Ross Papers, Box 40, Harvard Art Museum Archives, Harvard University.

### Of Foxy Paintings and Spiral Clouds

Born in Boston on January 6, 1858, Munsell received his initial exposure to the fundamentals of color in the Massachusetts public school system. The state legislature's 1870 "Act Relating to Free Instruction in Drawing" made art education compulsory in Massachusetts public schools, and Munsell seems to have thrived under the system, having been "awarded the mark of 'excellent'" in 1874 "for his 'flat copy' work" in the "Appleton Street Evening Class."<sup>30</sup> The next year, he enrolled in the Massachusetts Normal Art School – a college dedicated to training future art educators that had been established by the state legislature in 1872 in order to fill the need for art teachers produced by the Drawing Act. The school emphasized technical and practical skill as well as aesthetic refinement, and divided its curriculum into four "Classes": class "A" was devoted to "elementary drawing; class B to "form, color, and industrial design;" class C to "constructive arts;" and class D to "sculpture and design in the round."<sup>31</sup> Munsell was one of the few early students to complete all four classes, and after matriculating from MNAS as a Master of Art in 1881, he stayed on as an instructor, first in "anatomy and figure drawing," then in "modeling, casting and applied design."<sup>32</sup> On an 1885 fellowship to study in Paris, he exhibited in the Beaux-Arts salons of 1886, 1887, and 1888, and "received medals

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<sup>30</sup> JoAnne Marie Mancini, *Pre-modernism: Art-world Change and American Culture from the Civil War to the Armory Show* (Princeton: Princeton University Press, 2005) on pp. 55-59.

<sup>31</sup> Paul Dobbs, "The Association's First President: Albert H. Munsell, 1858-1918," *MCA Perspectives*, 2:4, Spring 1989, pp. 1-4.

<sup>32</sup> The library of the Massachusetts College of Art and Design contains a comprehensive collection of circulars from the early years of the MNAS, which list each year's students and the Classes that they completed. On Munsell's early positions at the MNAS see Dobbs, "The Association's First President," on pg. 2.

and special honors in anatomy, perspective and composition.”<sup>33</sup> Upon his return to Massachusetts in 1888, the MNAS circular featured his name prominently among the list of instructors, second only to the school’s principal.<sup>34</sup>

Public art education had been good to Munsell, but it also provided him with his first exposure to what he would come to deride as “traditional” color theories. Strictly speaking, of course, the curriculum of the MNAS in the 1870s was neither especially traditional – in the sense of being deeply rooted in the distant past – nor particularly un- or anti-scientific. Walter Smith – a champion of the Drawing Act, head of Art Education in Massachusetts, and first Director of the MNAS– personally advocated a self-consciously progressive approach to art education. Visual pedagogy of the past, Smith complained to readers of his 1873 volume, *Art Education, Scholastic and Industrial*, “concerned itself very little with unfolding to living men the practical value of physical laws which affect them day to day.”<sup>35</sup> Instead of basing their pedagogy in irrational beliefs handed down from “men in togas,” Smith suggested that art for the emerging American state would be based on principles of practical science: “what is here being done for science [at the “Boston Technological Institute” later to be renamed the Massachusetts Institute of Technology] [...] I want to see done for art, that the whole field of industrial arts pertaining to our daily lives may be thoroughly cultivated.”<sup>36</sup> Against critics who felt this to be an unreasonable demand – especially in the lower grades where students could hardly be expected to

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<sup>33</sup> “Albert Munsell,” *National Cyclopaedia of American Biography* (New York, James T. White and Co. 1904), on pg. 316.

<sup>34</sup> Dobbs, “The Association’s First President,” on pg. 2.

<sup>35</sup> Walter Smith, *Art Education, Scholastic and Industrial* (Boston: James R. Osgood and Company, 1873) on pg. 1.

<sup>36</sup> Smith, *Art Education*, on pg. 6.

have the facility for the manipulation of abstract figures that characterized scientific endeavor – Smith argued that, in fact, art and science were not so different. Though one with dealt the manipulation of the objective world though mathematical abstraction, and the other with manipulation of subjective sensations through aesthetic sensitivity, both were, in essence, a matter of the symbolic management of lived experience. Indeed, allowing himself a moment of philosophical rhapsody, Smith suggested that the essentially symbolic functions of abstract reasoning were part and parcel with the mimetic functions of drawing. “Writing” wrote Smith, “is, in fact, only drawing from memory; and the page I am now covering [...] is nothing more nor less than a drawing from memory of signs which visibly imitate the thoughts passing through my mind.”<sup>37</sup>

But while drawing was important, it was color, Smith thought, which “may be said to affect the mind more powerfully and directly than form.”<sup>38</sup> If representational drawing was intimately linked with knowing the world, color was essential for experiencing the world: “every color, as well as every combination of colors, has a sensible influence upon the feelings.”<sup>39</sup> As such, color was not unlike music. Like music, colors could be described in terms of a “major and minor key.”<sup>40</sup> Color in painting and design had laws, just as did music, and “[d]isregard of the laws of composition and proportion, in both, result in pain and confusion.”<sup>41</sup> Smith

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<sup>37</sup> Smith, *Art Education*, on pg. 8. For a different view of the relationship(s) between physicality, sensation and abstract reasoning in England and the United States in the mid nineteenth century, see Daniel J. Cohen, *Equations from God: Pure Mathematics and Victorian Faith*, Baltimore: Johns Hopkins University Press, 2007. Chapter two treats Benjamin Peirce, Charles’s father.

<sup>38</sup> Smith, *Art Education*, on pg. 180.

<sup>39</sup> *Ibid.*

<sup>40</sup> *Ibid.* on pg. 181.

<sup>41</sup> *Ibid.*

suggested that the key to both pleasure and pain – for color, anyway – was proper color balance. “Light decomposed,” he wrote, “results in color, – red, blue and yellow, and the tints in between them.”<sup>42</sup> In turn, combining red, yellow and blue in a painting in the same proportions in which they combined to produce white light would insure a harmonious – i.e. a pleasurable rather than painful – viewing experience. In looking to red, yellow and blue primary sensations to find the fundamental laws of color harmony, Smith felt he was following the lead of more or less current science, not least of all the notable Scottish physicist David Brewster, whose influential *Treatise on Optics* instructed that, “the solar spectrum consists of three spectra of equal lengths, viz. a *red* spectrum, a *yellow* spectrum and a *blue* spectrum.”<sup>43</sup> As with other laws of nature, the ratios in which these different “spectrums” mixed to provide white light could be enumerated: “[t]he proportion of pure color to produce light is yellow (3), red (5) and blue (8)” explained Smith.<sup>44</sup>

As part of his education at the MNAS, Munsell studied Smiths’ color theories, endeavoring to match chromatic knowledge and chromatic experience. But in doing so he discovered a problem. For one thing, in spite of the school’s exacting standards in color knowledge – to graduate from “Class C” one needed, among other things, to “define the terms “hot, cold, inherent, transient, contrasting and harmonizing colors,” as well as “tint, shade, tone neutral, positive, advancing and retiring colors;” give “the proportions of the surface in which primaries, secondaries, and tertiaries harmonize;” and state the proportions in which “pure color produce[s] white by

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<sup>42</sup> *Ibid.*

<sup>43</sup> David Brewster, *A Treatise on Optics* (Philadelphia: Blanchard and Lea, 1851) on pg. 109.

<sup>44</sup> Smith, *Art Education*, on pg. 182.

admixture” – it was precisely the lack of a definite nomenclature for color that led to confusion in the classroom.<sup>45</sup> Munsell recalled in 1912 that, “what one calls blue, another thinks to be purple-blue, or green-blue. Many allusions to other objects appear, such as baby-blue, sky-blue, king’s-blue, queen’s blue, blue ‘being born,’ and blue ‘dying’ as attempts to define a particular sensation.”<sup>46</sup> This made it difficult to teach students definite rules for creating harmonious compositions, in spite of Smith’s clearly defined proportions. For another thing, even if the three colors in their proportions could be correctly notated, Smith – relying on Brewster – had selected an outdated notion of color as the basis of his formal system of color harmony. In this sense, any painting relying on Smith’s proportions of red, blue, and yellow primaries was doomed to fail. “As a student,” remembered Munsell, “I was told that three parts of yellow, five parts of red and eight parts of blue, made harmony, although the formula failed to define what sort of red, yellow and blue would harmonize. Using the pigments in my box to illustrate this formula, [sic] resulted in a great excess of hot color (which painters term ‘foxy’) and the eye rebelled at a lack of balancing green-blue.”<sup>47</sup>

Fortunately, Munsell recalled, in 1879 he discovered Ogden Rood’s newly published monograph, *Modern Chromatics*. In a chapter on “the Colour Theory of Young and Helmholtz” Rood explained that while Brewster was “justly celebrated for his many and brilliant optical discoveries” and his theory of primaries could be

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<sup>45</sup> Examples of schedules and study questions for the different diploma programs in the MNAS during the nineteenth century can be found in *Circular of the Massachusetts Normal Art School*, A.H. Munsell Papers, Massachusetts College of Art Library and Archives, Massachusetts College of Art.

<sup>46</sup> Munsell, “Color and an Eye to Discern it,” on pg. 3.

<sup>47</sup> *Ibid.* on pg. 5.

found in “all except the most recent text books on physics,” it was nevertheless “not [...] difficult to show that it is quite without foundation.”<sup>48</sup> Instead of red, yellow, and blue fundamental colors, Rood instructed, the true primaries were red, green, and violet, in accordance with the physico-physiological theories of Thomas Young, James Clerk Maxwell, and Herman von Helmholtz. The disharmony of Munsell’s painting, in other words, was not the fault of the painter, but of a flawed formula based on unsound science. “It is hardly to be wondered,” Munsell concluded, “that my respect for those who had taught the old blunder fell near to the zero point.”<sup>49</sup>

Munsell found more than just painterly vindication in *Modern Chromatics*. The “balance” that was missing in his foxy painting could be ascertained through Rood’s formal analyses of color. Two ideas in particular caught Munsell’s attention. The first was the notion, explained in Rood’s chapter on “Methods of Color Arrangement” that color could be mapped in three dimensions. For this, Rood proposed a “color-cone” – really, two cones linked at the base – in which spectral colors girdled the wide equatorial region, gradually darkening and lightening as they moved towards opposite vertices, at the respective tips of which they gave way to pure black and pure white. This double cone adequately described the gamut and appearance of spectral colors of different luminosities. However, Rood cautioned his readers against attempting to physically construct a color system according to his specifications. For one thing, he noted, the pigments available with which to paint such a model could not come close to the spectral colors that it was supposed to represent; the model would therefore always skew darker than the colors that

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<sup>48</sup> Rood, *Modern Chromatics*, on pp. 108-109.

<sup>49</sup> Munsell, “Color and an Eye to Discern it,” on pp. 3-4.



appeared in spectra generated through diffraction gratings or prisms. For another thing, the scheme that Rood suggested allowed “no means of giving the colours a proper or rational distribution on the circumference of the circle;” and moreover “gives us no information about the effects that are produced by mixing together colours that are not complementary.”<sup>50</sup>

Rood’s solution to these problems was to treat colors “according to Newton’s suggestion, as though they were weights acting on the ends of lever-arms, and these arms have been taken of such lengths to bring the system into equilibrium.”<sup>51</sup> For example, the theory of red, green and blue primaries held that mixing equal luminosities of red and green light would produce yellow light of the same luminosity. One could translate this idea into a problem of mechanical advantage by imagining the luminosities of the red and green lights as weights which were arrayed at either end of a bar of arbitrary length; the balance point of the bar would show the position of yellow – in this case, at the midpoint. Orange, on the other hand, which was the result of mixing red and green light in a ratio of 7:3 would be located at a point  $\frac{3}{7}$  closer to the red weight than the green. “Now,” continued Rood, “this is a process which can actually be carried out in practice.”<sup>52</sup> A spinning disk fitted with adjustable segments of paper painted in “vermillion, emerald-green, and “artificial ultramarine blue” pigments – a so-called “Maxwell disk” – would allow one to ascertain a complete color chart predicated on an equilateral triangle. Since white light – as Newton had demonstrated – was composed of all spectral colors,

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<sup>50</sup> Rood, *Modern Chromatics*, on pg. 218.

<sup>51</sup> *Ibid.* on pg. 225.

<sup>52</sup> *Ibid.* on pg. 219.

and all spectral colors could be derived from three primaries, then a mix of the correct proportions of those three primary colors should yield white – or at least a neutral grey that could be treated as white, owing to the imperfect reflectivity of the pigments. The location of white with respect to the vertices of the triangle would yield the balance point of the color diagram, from which the positions of other colors could be determined. For instance, by spinning his Maxwell disk and adjusting the paper sections, Rood found that “33·46 parts of vermillion, with 33·76 of emerald-green and 29·76 parts of ultramarine, gave a grey similar to that obtained by mixing 28·45 parts white with 71·55 of black [...] The equation then reads:  $33·46 R + 33·76 G + 29·76 B = 28·45 W$ ”<sup>53</sup> Given a triangle with sides of 200 units, Rood found the balance point – the white point – of the system first by determining the point of balance (*a*) between R and G. This could be used to produce a line, *aB* across the triangle. Finding the balance point between (R+G) and B along line *aB* would yield the position of white. This white point was a sort of fulcrum, with those colors that mixed to produce grey – i.e. complimentary colors – placed on different sides of the balance point. As a final refinement, Rood suggested that one needn’t arbitrarily assume that every pigment – including the baseline vermillion, emerald-green, and artificial ultramarine blue pigments – had the same luminosity, and suggested a method by which each pigment took a coefficient, which indicated the pigment’s distance from the center of the chart and therefore its luminosity.

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<sup>53</sup> *Ibid.* on pg. 224. Rood did not include the proportion of black that combined with white to make the comparative grey because he was concerned with the amount of light reflected from the spinning apparatus. The black could be taken as an element that mimicked the imperfection in the vermillion, green and ultramarine pigments, and could be ignored.

In Rood's proposal, Munsell found his wished-for system of balance – not simply an aesthetic balance, but a metaphorical balance based on treating colors as though they had mass. Following Rood, Munsell fabricated his own color solid – a tiny double-tetrahedron with red, green and blue pigments at the corners, which graded to white and black at either of the points opposite the joined bases. For Munsell, Rood's system of physical and geometrical balance was part and parcel with a scientifically validated system of aesthetic balance. Just as color could be organized based on the proper experimental determination of balanced hues, so too did these systems hold the key to creating balanced sensations of color harmony in viewers. As “[t]he eye is determined upon approximate balance of these red, green and purple-blue elements,” Munsell speculated, “[t]his condition of normal balance is the source of visual contentment.”<sup>54</sup> As he wrote in the 1907 edition of *A Color Notation*, “All our ideas of color harmony are based upon this fundamental relation.”<sup>55</sup> Munsell's early tetrahedral model could be made to act as sort of a three dimensional Maxwell disk: “twirled between the thumb and forefinger, this model caused the three colors to melt into a tolerable grey,” he told the *American Psychological Association* in 1909. However, “the sequence from white to black looked irregular, and seeing this was due to the fact that carmine and ultramarine are much darker pigments than emerald green, the solid was repainted with the first two placed lower down, which produced a more satisfactory gradation.”<sup>56</sup>

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<sup>54</sup> Munsell, “Color and an Eye to Discern it,” on pg. 4.

<sup>55</sup> Albert H. Munsell, *A Color Notation*, 2<sup>nd</sup> edition (Boston: George Ellis and Co., 1907) on pg. 51.

<sup>56</sup> Albert Henry Munsell, “A Measured Training of the Color Sense,” *Education*, 29:6, Feb. 1909, pp. 360-380, on pg. 361.

Between 1881 and 1890, Munsell's interest in experimenting with abstract models of color seems to have diffused somewhat as he worked on cultivating his reputation as a painter and educator in Boston's burgeoning art scene.<sup>57</sup> This did not mean, however, that he dropped his inquiry entirely. In 1885, for example, he exhibited "Chloris Calls," a "decorative sketch" in watercolor, at the gallery of the elite Boston Art Club (figure 5.1).<sup>58</sup> A fairly conventional allegory of spring featuring an elegantly draped woman grasping a clutch of gladiolas, the painting also depicted an unusual structure somewhat like a large sundial, which Munsell later described as an early musing on a "spectrum circuit [arranged] on the rim of a circle – balancing yellow and blue, [sic] against red and purple."<sup>59</sup> During his sojourn in Paris, he read Chevreul's 1838 *De la loi du Contraste Simultané des Couleurs* in the Beaux-Arts library, and visited the chemist's outpost at Gobelins in order to "see [his] scale of yarns."<sup>60</sup> In his diary, Munsell records having given his students a "sketch of various diagrams and models to illustrate color balance" around 1889, though he doesn't specify what sort of diagrams he produced, nor does he note the nature of his thoughts on balance in the late 1880s.

As he worked his way through the upper crust of Boston's art world – becoming a member of the exclusive St. Botolph Club as well as the Boston Art club – Munsell made the acquaintance of Denman Ross, a historian, painter and art educator. Born in 1853 to a wealthy Cambridge family, Ross took his PhD in history

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<sup>57</sup> On Boston's art world at the turn of the century see, Mancini, *Pre-Modernism*; also Nancy Allen Jarzombek, *Boston Art Club 1855-1950* (Boston: Vose Gallery, 2000).

<sup>58</sup> *Catalogue of the Thirty-Second Exhibition of the Boston Art Club Water Colors, Black and White Drawings, and Sculpture, Held at the Club Gallery* (Cambridge: Riverside Press, 1885) on pg. 18.

<sup>59</sup> Diary of A. H. Munsell, n.d. (1899?).

<sup>60</sup> Diary of A. H. Munsell, n.d (1899?).

at Harvard, working with Henry Adams, whose “scientific” approach to history Ross emulated in his thesis, published in 1883 as *The Early History of Land-Holding among the Germans*.<sup>61</sup> Although his dissertation generated a great deal of discussion among academic historians for its “scientific” approach to history, Ross shelved his historical work in 1884, redirecting his attention art and aesthetics. Following a six-year string of trips to European cities in which he studied canonical masterpieces of Western art and architecture, Ross returned to the United States with the notion of teaching aesthetics as a science, in much the same vein as he had pursued history. As he put it in his 1907 monograph, *A Theory of Pure Design*, “[m]y purpose, in scientific language, is to define, classify and explain the phenomena of Design” – among which phenomena, the perception of color was an important component.<sup>62</sup>

Ross’s color system defies concise summary, but in brief, he conceived of colors as having an essentially geometrical relationship to one another, in much the same way as musical notes. To begin with, Ross proposed that all color relations – that is, the organization of all “tones” – were governed by two basic principles: “value” and “color.” “Value” was the degree of lightness or blackness in a color, which Ross conceived as a nine fold scale of grays which he notated as “white (Wt), High Light (Hlt), Light (Lt), Low Light (LLt), Middle (M), High Dark (HD), Dark (D), Low Dark (LD), [and] Black (Blk).”<sup>63</sup> Each of the grays could contrast with one another to produce thirty-six sets of contrasts, like so:

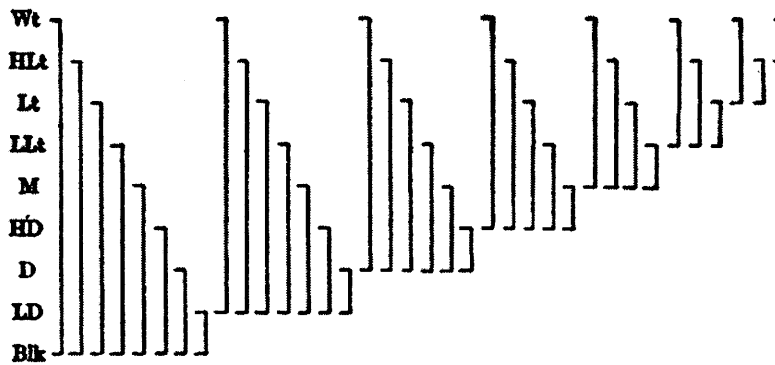
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<sup>61</sup> Denman Ross, *The Early History of Land-Holding among the Germans* (London: Trübner & Co, 1883).

<sup>62</sup> Denman Ross, *Theory of Pure Design* (Boston: Houghton Mifflin, 1907) on pg. v.

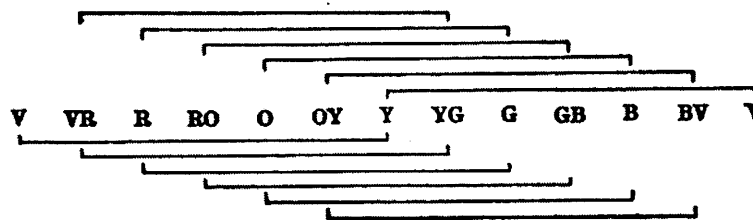
<sup>63</sup> Denman Ross, *The Painter’s Palette* (Boston: Houghton Mifflin, 1914) on pg. 2.

**CONTRASTS OF THE SCALE OF VALUES**



“Colors,” similarly, could be divided into twelve categories, according to the “spectrum band,” which Ross labeled “R, RO, O, OY, Y, YG, G, GB, B, BV, V, VR” (Ross didn’t specify why he elected to omit “purple” from his list of notations). These colors contrasted with one another “at the interval of the seventh” – that is, any two colors seven increments away from one another would mix to produce one of the nine “values:”

**COMPLEMENTARY COLORS  
AT THE INTERVAL OF THE SEVENTH**



Based on these scales, Ross proposed that any color could be named according to its value, color, and “intensity” – a quality which Ross declined to define, except to note that when a color was called “Low Light Blue, three quarters (LLtB  $\frac{3}{4}$ ) it meant that the color was “Blue in the Value of Low Light, three-quarters intensity.”<sup>64</sup> If more

<sup>64</sup> Ross, *The Painter’s Palette*, on pg. 17.

than a little bit byzantine, Ross's system became an accepted part of the teaching of design and painting within Harvard's Fine Arts Division, in which Ross began teaching after 1890.<sup>65</sup> Indeed, in 1904 *The School Arts Book* – a Boston-based journal of art education edited by Henry T. Bailey, a colleague of both Milton Bradley and Munsell's – offered an effusive assessment of Ross's approach to art education, writing "[n]ot often does one find the most thorough and scholarly instruction, enriched by the finest obtainable example of artistic achievement, given by a man whose theories are embodied in his own works, and whose charming personality is a perpetual inspiration to nobler living."<sup>66</sup>

Not unlike Munsell's, the point of Ross's system was to allow "the painter to convert his palette into an instrument of precision and to make the production of effects of light and color a well-ordered procedure."<sup>67</sup> Both Munsell and Ross, that is, strove to find a way of correctly defining the rules of color harmony according to science. But whereas Munsell felt that any system of color ought necessarily to bridge both the mental processes and the sensory physiology of the viewer, Ross, as art historian Marie Frank points out, demanded that "art remain[n] a product of the mind and [...] not simply a sensory pleasure."<sup>68</sup> This did not mean that Ross ignored his contemporaries' interest in the intersections between the sensual, the cerebral, and the scientific; indeed, quite the opposite – Ross read Rood's *Modern Chromatics* with interest, and badgered his fellow Harvard professors William James, George

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<sup>65</sup> Marie Frank, "Denman Ross and the Theory of Pure Design," *American Art*, Fall 2008, pp. 73-89, on pg. 73.

<sup>66</sup> Henry Turner Bailey, "Editor's Notes," *School Arts Book*, March 1904, on pg. 336.

<sup>67</sup> Ross, *The Painter's Palette*, on pg. v.

<sup>68</sup> Frank, "Denman Ross," on pg. 74.

Santayana, and Hugo Munsterberg about the possible applications that their research on perception might have in the field of design. (James quipped that Ross was “saved from being a pedant only by having real feeling.”)<sup>69</sup>

But for Ross, a tremendous gulf distinguished the worlds of that which could be felt and that which could be thought. As he explained in an undated manuscript entitled, “Vision and Touch,”

“The solid realities of nature, life and art, the objects, people and things including ourselves we never see except as reflections of color in light. As reflections we touch them, handle them, and measure them but we never see them. What we touch we never see. What we see we never touch. As perfumes are intangible so are colors as we see them [...]”<sup>70</sup>

(He also considered that “among the solid realities that we touch but never see are the pigments we use in the practice of painting. The painter never sees the materials that he uses” – but he struck out the idea on the manuscript page.)<sup>71</sup> In this stringent appraisal of the relations of sensation to cognition, then, Ross didn’t so much reject the importance of the physiology of the senses as he drew a sharp line between objective reality and subjective experience. Indeed, Ross was suspicious of the general amenability of all physical and mental sensations, not just vision, to the tools of science – wondering, for instance, “if hunger is merely the feeling of hunger, how can it be measured accurately?”<sup>72</sup>

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<sup>69</sup> Quoted in Frank, “Denman Ross,” on pg. 85.

<sup>70</sup> Denman Ross, “Vision and Touch,” n.d., Denman Waldo Ross Papers, Box 39, Harvard Art Museum Archives, Harvard University.

<sup>71</sup> *Ibid.*

<sup>72</sup> Denman Ross, “Measuring Hunger,” n.d. 1923, Denman Waldo Ross Papers, Box 29, Harvard Art Museum Archives, Harvard University.



Given the ultimately intangible nature of perceptual reality, one might reasonably presume that observers were therefore islands unto themselves – trapped within their own perceptual versions of Plato’s cave. Indeed, in an early draft of his 1912 monograph, *On Drawing and Painting*, Ross declared, “I am no more than a point in space and this is true of everybody” – a startling pronouncement for those who took their physiological personhood seriously.<sup>73</sup> The way out of the isolation of the individual cave, it seemed to Ross, came from mathematics – and particularly mathematics as explained in work of Henri Poincare, whose 1905 monograph, *La valeur de la science, (the Value of Science)*, Ross interpreted to mean, “what we call objective reality is in the last analysis what is common to many thinking beings and could be common to all. This common part, we shall see, can only be the harmony expressed by mathematical laws.”<sup>74</sup> This mathematical “harmony” – expressed in terms of regularity and rhythm – governed not only aesthetic experience, but also the most fundamental physiological processes. In an undated note Ross wrote,

I go to walk. I don’t think of it but I am taking equal steps in corresponding and equal measures of time [...] My eating is governed by a quite regularly recurring hunger due to a regularly recurring exhaustion of physical energy [...] All these rhythms I have described, – of pulsations in the circulation of the blood, of breathing, of walking, and other activities, of eating, go on as the

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<sup>73</sup> Denman Ross, Typescript to “On Drawing and Painting,” n.d., Denman Waldo Ross Papers, Archival Material Box Q, Harvard Art Museum Archives, Harvard University.

<sup>74</sup> *Ibid.*

main rhythms of a still greater one, of alternating between consciousness and unconsciousness.<sup>75</sup>

The physiological rhythms of everyday existence, that is, harmonized with the rhythms of the physical universe; and the experience of color was part and parcel with this universal rhythm. The only means of reliably expressing the experience of color, therefore, was through the sorts of mathematical relationships that governed other sorts of harmonies – particularly the regular intervals found in music, though in other geometrical forms as well. As such, Ross was less interested in color as a psychophysical quantity, and more as an absolute abstraction – a mental construct, which could only be liberated through formal expression; not through attention to the physics or physiology of color perception.

Munsell met Ross sometime in 1890, possibly through their mutual friendship with Joseph Lindon Smith, a New Hampshire-based painter known for his work documenting the excavation of the pyramid at Giza in Egypt. Ross and Munsell went sketching together at the Shoals in New Hampshire, and later, in 1892 travelled to Venice, where the pair seems to have walked around making sketches and talking about color schemes. On an earlier visit to Venice – likely in 1891 – Ross had carefully noted color schemes that he had come upon as he examined Venetian art and architecture, including a “scale of value” running from white to black, with different orange, red, and blue at different points of intersection:

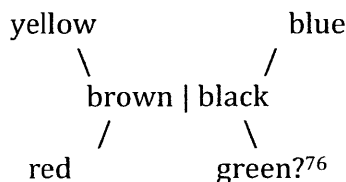
- 1 white
- 2 orange & white
- 3 claret cobalt? And white

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<sup>75</sup> Denman Ross, Untitled Mss. n.d., Denman Waldo Ross Papers, Box 39, Harvard Art Museum Archives, Harvard University.

4 orange  
5 claret & orange  
6 cobalt  
7 black

In another space, he simply jotted:



As they meandered around Venice a year later, Munsell recalled, he and Ross revisited the topic of color systems, “talk[ing] over a systematic color scheme for painters, so as to determine mentally on some sequence before laying the palette.”<sup>77</sup> Munsell’s discussions with Ross appear to have reinvigorated his interest in chromatic formalisms.

During a studio visit in 1898, Ross found Munsell struggling to devise a formal device for analyzing the color scheme of a painting (possibly Munsell’s “War Cloud, which Munsell painted at the Shoals, and mentions having shown to Ross in 1898). For Ross, the problem presented by Munsell’s painting seems to have been how to “to pass from white to black through all possible colors; keeping the colors in their natural relationships shown in the spectrum.”<sup>78</sup> Thinking about his own system of colors – cycles of spectral colors intersecting with cycles of neutral values, Ross envisioned mapping Munsell’s painting as a spiral, with spectral colors as radii diverging at fixed angles from the center of the spiral. The points at which the radii

<sup>76</sup> Denman W. Ross, Venice Diary, n.d. 1887, Denman Waldo Ross Papers, Harvard Art Museum Archives, Harvard University.

<sup>77</sup> Diary of Albert H. Munsell, n.d. 1899?,

<sup>78</sup> Denman Ross, Note: “Color Spirals,” 10 Jan. 1898, Denman Waldo Ross Papers, Box U/V and Box T, Harvard Art Museum Archives, Harvard University.

crossed the line of the spiral, Ross proposed, indicated the harmonious mixture of a given spectral color and white or black. The solution evidently impressed Munsell, and he set to work applying Ross's two-dimensional model to Rood's three chromatic dimensions.

On April 14, 1899, Munsell applied for a patent for a "Color Sphere and Mount" – a "new and useful Device for the Study and Arrangement of Colors" that bore distinct features of Ross's influence (figure 5.2). Described by Munsell as a three-dimensional "chart" of color, the invention consisted principally of a globe mounted between two pins, around the equator of which Munsell had arranged "six equidistant colors of the solar spectrum – red, yellow, green, blue, violet and purple;" these colors were brightest around the middle of the surface of the globe, and slowly transitioned into "white at the north (or uppermost) pole and to black at the opposite pole."<sup>79</sup> A mirror fixed the two pins in place, and allowed users to view most of the globe at the same time. The intent of his invention, Munsell explained, was to "present a sequence of colors as they exist in nature and to present to the eye an orderly arrangement of colors in a great variety of sequences" – or, more precisely, to "have a sequence of colors as they are found related in the spectrum and to have such a sequence in every value or gradation of colors and to have a sequence changing not only in color, but in value, at each successive stage."<sup>80</sup> In his notes prior to submitting his patent application, Munsell had revealed in the ideal form of color that the sphere represented: the sphere was to be conceived of as

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<sup>79</sup> Albert Munsell, 1900, *Color Sphere and Mount*, U.S. Patent no 640, 792, filed 14 Apr. 1899, and issued 9 Jan 1900, on pg. 1.

<sup>80</sup> *Ibid.*

“built up of an infinite number of parallel superposed color circles.”<sup>81</sup> Different color relations could “be traced through the substance of the sphere – by means of sections, segments, sectors, spherical triangles, chords, radii or other elements of the sphere.”<sup>82</sup>

To delineate these sequences in his physical model, Munsell inscribed his sphere – in a manner reminiscent of Ross’s spiral diagram – with lines that traversed its surface angularly from pole to pole. Any one of these spirals traced a sequence of colors between black and white – say, from white, to light red, to less-light orange, to bright yellow, to darker green, to even darker blue, to very dark purple, to black – and the precise colors discovered therein were, Munsell asserted, necessarily aesthetically harmonious. Moreover, as one traced a given color longitudinally down the side of the sphere, the intersections of the inscribed spirals yielded a graded scale of values, not unlike both Ross and Rood’s systems. These values could be notated “mathematically” such that, as Munsell put it in his patent, “R<sup>1</sup> R<sup>2</sup> R<sup>3</sup> R<sup>4</sup> R<sup>5</sup> R<sup>6</sup> R<sup>7</sup> represent all gradations or “values” of red from white to black. Y<sup>1</sup> Y<sup>2</sup> Y<sup>3</sup> Y<sup>4</sup> Y<sup>5</sup> Y<sup>6</sup> Y<sup>7</sup> represent all values of yellow, and the intermediate space will present similar gradations of the intermediate color – orange.”<sup>83</sup>

The United States Patent office granted Munsell his patent on January 9, 1900. Although two years later Munsell wrote to Ross to acknowledge that “a spiral diagram which you made at my studio several years ago [...] led me to try some

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<sup>81</sup> Diary of Albert H. Munsell, n.d. 1899.

<sup>82</sup> Diary of Albert H. Munsell, n.d. 1899.

<sup>83</sup> Albert Munsell, 1900, *Color Sphere and Mount*, U.S. Patent no 640, 792, filed 14 Apr. 1899, and issued 9 Jan 1900, on pg. 1.

reversed spirals and later suggested the color sphere,"<sup>84</sup> Ross, for his part was unimpressed. Shortly after Munsell took legal ownership of the idea for the color sphere, Ross grumbled in his notes that he himself had "had Munsell's idea at this time before he had it patented [in? it's] a mistaken idea. I soon got past it."<sup>85</sup>

### Turning the Color Sphere

Munsell, however, did not so quickly get past the idea, finding in the color sphere an apt demonstration, as he jotted in his diary, of Hegel's notion of "the free and adequate embodiment of an idea – in a form peculiarly appropriate to the idea itself."<sup>86</sup> This said, however, when it came to realizing the system described in his patent in a form that would be both practically useful and valid according to the precepts of science, Munsell was left with more questions than answers. In March of 1900, he wrote to Rood, asking for "scientific authority" and wondering, "what could be claimed for the sphere."<sup>87</sup> How, that is, ought his colors be organized? What precisely, was the basis of his nomenclatural system? How did the viewer fit into his system, and how did it gibe with the understanding of vision espoused by Munsell's scientific peers? Rood wrote back to advise that Munsell ought not call his sphere "scientific," recommending instead that Munsell claim that his system "practically represents a scientific arrangement of colors" – though, Rood assured his interlocutor, he had "no doubt whatever of its value to the teacher and the artist."<sup>88</sup>

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<sup>84</sup> Diary of Albert H. Munsell, copy of a letter dated 30 Jan. 1902.

<sup>85</sup> Denman Ross, "A System of Color-Values or Tones," July 1, 1901, Denman W. Ross Archival Material Box U/V and box T, Harvard University Archives, Fine Art Library.

<sup>86</sup> Diary of Albert H. Munsell, n.d. approx. 7 Jan. 1901.

<sup>87</sup> Diary of Albert H. Munsell, 10 Nov. 1900.

<sup>88</sup> Diary of Albert H. Munsell, 10 Nov. 1900.

If Munsell was discouraged by Rood's tepid response, he did not make note of it, and pressed on trying to develop a scientific warrant for his system.

The first problem facing Munsell was to determine the precise basis for his color ordering system – the thorny issue, that is, of selecting the baseline primary hues that made up the equator of his color circle. It was true that through his study of Rood's *Modern Chromatics*, Munsell had become an adherent to the theory that three primary receptors in the retina of the eye were the source of all color sensations, and that these receptors were keyed to red, green and blue sensations. Indeed, this very point had been the crux of a bitter argument between Munsell and a Robert D. Andrews – a Boston architect who wished to collaborate with Munsell on a color sphere based on “red, yellow and blue on three axes mutually perpendicular.” After a heated discussion one evening in his parlor, Munsell rebuffed Andrews, declaring that if such colors were the principle basis of Andrews's theory, “then your path and mine can never cross in this development of color relations.”<sup>89</sup> This said, as Ridgway, Pillsbury, Bradley and Ladd-Franklin had all discovered, understanding the physiology and psychology of color was

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<sup>89</sup> Diary of Albert H. Munsell, 27 May 1901. There is little biographical information on Andrews, and his identity as Munsell's rival is therefore somewhat uncertain. However his name appears as a fellow of the Society of Architects in the catalog of an 1886 show at the Boston Art Club along with an ink wash illustration by him; Munsell, of course, was a member of the Club, so it is possibly that they became acquainted through the club or its associated social circle. (See *Catalogue of the First Exhibition Under the Auspices of the Boston Society of Architects, Held at Boston Art Club Gallery*, (Boston: Alfred Mudge and Son, 1886) pg. 24 and pg. 33). At the same time, Addison Henry Clark's *Architect's Handbook on Cements* further supports the conjecture that Robert D. Andrews the architect was, in fact, Munsell's rival, insofar as it is dedicated to “Mr. Robert D. Andrews, Architect [...] with the earnest desire that his highest hopes may be realized, for the general advancement throughout our land of higher technical education in the mechanical arts” – placing Andrews's interests in arts education in concert with Munsell's (Addison Henry Clark, *Architect's Handbook on Cements* (Baltimore: William Wirt & Son) 1899).

formidable enough; but translating the murky world of psycho-physiological experience into discrete and orderly linguistic units could be a herculean endeavor.

Munsell's patent for the color sphere reveals little of his initial thinking on the matter, except to suggest that, early in the development in the system, his preoccupation with mapping colors according to spirals outweighed his interest in systematic color arrangement according to the tenets of psychophysics. (It is worth noting, too, however, that Munsell rushed to submit his patent under the threat that Andrews, or perhaps Louis Prang, might beat him to the punch – therefore, the patent might simply reflect fast work rather than a statement of intent).<sup>90</sup> The proposed arrangement of spectral colors around the equator of the sphere diagramed in Munsell's patent, for example, does little to preserve what he would have thought of as sets of complementary colors according to the more or less conventional color triangle found in *Modern Chromatics* and elsewhere. According to Rood, red neutralized against a kind of bluish green; blue neutralized against yellow; and green neutralized against a sort of reddish purple. For reasons that he did not specify, however, on his 1900 color sphere diagram Munsell placed red opposite blue; green opposite purple; and violet opposite yellow – thereby seeming to ignore the complementary aspects of his color system in favor of some other method of organization. Given the preponderance of “cool” colors in Munsell's selected scheme, it is possible that he was considering his sphere at this point as primarily a means by which painters might avoid composing “foxy” palettes for their paintings by using the spirals etched along its surface to navigate through principally “cool” regions of

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<sup>90</sup> Diary of Albert H. Munsell, 27 May 1901.



color. Indeed, the color wheel depicted in his painting “Chloris Calls” had attempted a similar division, “balancing yellow and blue,” Munsell recalled, “against red and purple.”<sup>91</sup> Nevertheless, given that one of Munsell’s arguments for patent protection was that his sphere was “arranged in [...] scientific order” this comparative lack of scientific arrangement was a distinct problem.

Color sensations as understood through psychophysical research, Munsell quickly discovered, did not translate easily into precise abstract color terms, which greatly complicated the question of Munsell’s baseline divisions of his sphere. A December 1901 entry in Munsell’s notebook, for instance, reads: “Query: shall cir[cle] be ten colors in  $3 \frac{1}{7}$  steps, or three colors in  $10 \frac{1}{2}$  steps each [?]” The “total balance” of the system, Munsell noted, had to remain the same, allowing only for a “shift in names and divisions.”<sup>92</sup> Munsell’s friend, Benjamin Ives Gilman – secretary of the Boston Museum of Fine arts and one of Peirce’s graduate students at Johns Hopkins along with Ladd-Franklin – approved of the idea of basing the system off three fundamental sensations, but noted that it would require the “loss of popular names yellow and purple.”<sup>93</sup> Munsell weighed the ideas of “three colors in ten steps each” or “six colors in five steps each;” versus “five colors in six steps each” or “ten colors in three steps each,” noting that the former grouping allowed for “3 fundamental sensations,” while the latter suggested “5 abstract names” – though it is not clear which he viewed as more advantageous at the time.<sup>94</sup> In March of 1900, Munsell visited Rood in the physicist’s office at Columbia, bringing with him models

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<sup>91</sup> Diary of Albert H. Munsell, n.d. 1900?

<sup>92</sup> Diary of Albert H. Munsell, 19 Dec. 1901.

<sup>93</sup> *Ibid.*

<sup>94</sup> Diary of Albert H. Munsell, 19 Dec. 1901.

of spheres divided into three sections and four sections; Rood felt that the “the division by four [was] most satisfactory.”<sup>95</sup> Henry T. Bailey, Bradley’s friend from Springfield, likewise thought that “the 4 division gives the best orange and purple.”<sup>96</sup> A “Dr. House,” meanwhile, at Johns Hopkins University, believed that Munsell should base his system off of “Herring’s [sic] theory of six fundamental sensations,” implying white and black poles, with red and green and blue and yellow opponent pairs – that is, a fourfold division of the sphere’s equatorial circuit.<sup>97</sup> This left Munsell with a great deal of advice, all of which, however, led only to the conclusion that the limited number of abstract color words available in English did not match well with the needs of constructing a psychophysical color solid. As such, Munsell struggled to maintain his claim that his sphere presented “equidistant” hues for ease of notation, with the facts, as he understood them of psychophysics, and the vagaries of abstract language.

Munsell ultimately relied on a combination of eclectic reasoning and semantic dogmatism to guide his sectioning of the sphere. In a diary entry of April, 1900, Munsell noted that he had “[a]ttempted division by 5 in order to use decimal system 100° from any color to its compliment – right or left handed.” This same rule, Munsell noted, could apply to the values axis, allowing “100° from black to white.”<sup>98</sup> All “central” color names would consist of “1 word” – Red, Purple, Blue, Green or Yellow. Between each of the five “central” words, Munsell proposed to place three “intermediates,” consisting of two words apiece: between the red and purple

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<sup>95</sup> Diary of Albert H. Munsell, 29 Mar. 1900.

<sup>96</sup> Diary of Albert H. Munsell, 2 Apr. 1900.

<sup>97</sup> Diary of Albert H. Munsell, 17 Apr. 1900.

<sup>98</sup> Diary of Albert H. Munsell 5 Apr. 1900,

“central” colors, for instance, Munsell situated “purplish red,” “red purple,” and “reddish purple” – not unlike the system advocated by Bradley and Pillsbury. In this way, each of his hue divisions could be given 10% of the hue circle. Moreover, the system seemed to mesh better with the understanding of color propounded by the psychophysicists that Munsell admired – “Red” and “blue green” shared a diameter, as in Rood’s diagram; “Green” was opposite “Red purple,” as in Rood’s diagram; and “Blue” was opposite “Yellow Red” (i.e. “orange”) – which, if it didn’t concord precisely with Rood’s diagram (which suggested the opposite of blue was a yellow close to that of a buttercup), was nevertheless a vastly better pairing blue with red as he had in his original patent. And while it was true that Munsell had to eliminate popular color names like “orange” and “violet” in order to introduce a sense of decimal regularity in his system – since there were no single words that meant “blue green,” “green yellow,” or “purple blue” in the same way that “orange” indicated “yellow red” and “violet” indicated “red purple” – this was an acceptable loss. After all, reasoned Munsell, “orange” and “violet” were not really abstract color names, but rather “refer to [...] variable product[s] of the vegetable kingdom.”<sup>99</sup> Munsell would not fall into the same trap as had Ridgway, and since “violet” and “orange” tended to “excite other ideas not kindred with color” – such as the arbitrary surfaces of natural objects – these words would be a liability in any system dedicated to the mental training of the color sense.<sup>100</sup>

Over subsequent months and years, Munsell occasionally vacillated in his commitment to the five-fold path, but the idea stuck. As soon as he had produced a

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<sup>99</sup> Munsell, *A Color Notation*, 1905, on pg. 55.

<sup>100</sup> Diary of Albert H. Munsell, 19 Sept. 1905.

sketch of the five-fold color scheme, Munsell sent a diagram of it to Rood. On the same illustration Munsell indicated to Rood the possibility of a 100° value scale ranging from black to white, prompting Rood to write back to say that “the five fold idea seems a good one.”<sup>101</sup> At the same time, Munsell found additional, if somewhat oblique, support, in the writings of Ralph Waldo Emerson, who Munsell quoted as having observed that “nature loves the number five” – which Munsell interpreted as an endorsement of the validity of his five-fold division from one who understood nature in both ideal and empirical ways.<sup>102</sup> Between 1900 and 1904, Munsell abandoned the notion of 100° segments to either side of a given color, deciding instead to base his system on his five principle hues, plus their main intermediaries – i.e. “red yellow,” “yellow green,” “green blue,” “blue purple,” and “purple red.” Each of these ten divisions he further subdivided into ten sections to make 100 equally spaced divisions. A color could therefore be notated first by classing it among one of Munsell’s ten main colors and then by determining into which of the ten sections within that color best described it. A hue like that of a ripe strawberry, for example, might fall somewhere around the 5R section of the color sphere’s equator – that is directly in the middle of “red” category (R), and leaning neither towards 1R, which was close to the “Red-Purple” zone of the color circle, nor leaning towards 10R, which was close to the yellow part of the hue circle.

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<sup>101</sup> Diary of Albert H. Munsell, 16 Apr. 1900.

<sup>102</sup> Diary of Albert H. Munsell, n.d. possible Apr. 1900. Munsell might well have identified with the protagonist of Emerson’s poem, who walked through the forest “Ponder[ing] shadows, colors, clouds” – though the modesty that Emerson attributes to his protagonist (“What he knows, nobody wants,—/ What he knows, he hides, not vaunts”) would be difficult to ascribe to Munsell, given both Munsell’s commitment to practical utility and his limitless capacity for self promotion. For the original poem, see Ralph Waldo Emerson, “Woodnotes,” in *Poems* (Boston: Houghton Mifflin Co., 1900) pp. 43-57, on pg. 44.

Having provisionally decided upon the divisions of the sphere, Munsell's next problem was to specify precisely the colors that were to be signified by each spectral division. This problem was, in one sense, similar to the one that had faced Bradley and Pillsbury – how does one know which of the infinite varieties of “red” is actually *red*; which “blue-green” is actually “*blue-green*”? To find an answer to his questions of color definition, Munsell first turned, pragmatically enough, to the *Century Dictionary* – an eight volume tome published between 1881 and 1890 with the charge of, among other things, providing a “general dictionary of the English language [...] serviceable for every literary and practical use” including a “very complete presentation of the present status of human knowledge of [the physical] sciences” – of which the study of color was explicitly a part.<sup>103</sup> William Dwight Whitney, principle editor of the *Century*, solicited prominent academics to provide entries for his dictionary, and for definitions relating to color had turned to Charles Peirce – Gilman and Ladd-Franklin's former mentor and Rood's close friend – who had pursued his own line of color research, on and off, since the 1870s. For his entries in the *Century Dictionary*, Peirce elected to describe color in both qualitative and quantitative terms – thus “green” he defined as “[t]he color of ordinary foliage; the color seen in the solar spectrum between wavelengths 0.511 and 0.543 microns.”<sup>104</sup> Similarly, “yellow” defined as “the color of gold, butter, the neutral

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<sup>103</sup> “Preface,” *Century Dictionary*, Vol I. (New York: the Century Company, 1891) pp. i – xvi, on pp. i and pp. xiii – xiv.

<sup>104</sup> Charles S. Peirce, “Green,” *Century Dictionary*, 1891. Peirce went on to note that “according to the theory generally accepted by physicists, the sensation of pure green is a simple one. This sensation cannot be excited alone in a normal eye; but the spectrum at wavelength .0524 micron, if the light be very much reduced, probably excites the sensation with some approach to purity.”

chromates of lead, potassa, etc. and of light of wave-length about 0.581 micron.”<sup>105</sup>

Munsell dutifully copied down both the descriptions and wavelengths of each of his five central colors as specified by Peirce, and continued to refer to them throughout his color work whenever basic definitions of spectral hues were required.

But where defining colors according to wavelength had worked well for Bradley and Pillsbury – as Munsell was well aware, having purchased a set of Bradley’s “Spectrum Standard Colors” around 1899 – wavelength was unsuitable for Munsell’s purposes for two reasons.<sup>106</sup> For one thing, the relationships among colors in Bradley’s system were, in essence, two dimensional – that is, any two adjacent colors in Bradley’s system had to relate to one another in terms of incremental changes in lightness and hue, but they did not necessarily need to reflect a consistent rule for relationships across all colors. This was not so for Munsell’s system, in which it was imperative that the relationship between any two colors could be repeated for any other two colors. Every pair of complementary colors, for instance, had to be an equal radial distance from any other in order to ensure that all colors across the color sphere from one another combined to form a neutral gray – an aspect of color relationships not addressed by Bradley’s system, which was, strictly speaking, just an account of single colors, even if it was based on the spectrum. The same principle governed Munsell’s fixation on the spirals extending down the sides of his sphere: any one spiral of a given pitch drawn down the side of the color sphere would describe essentially the same harmonious relationship as any other spiral of that same pitch – the colors would be different, but the principle

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<sup>105</sup> Charles S. Peirce, “Yellow,” *Century Dictionary*, 1891.

<sup>106</sup> Diary of Albert H. Munsell, 10 Nov. 1900.

of harmony (as described by the distances between spirals, and so forth) would be the same. These sorts of relationships were easy to imagine in theory, but in practice turned out to be far trickier to govern. As Ross had noted, apropos of his own complicated system of systematic color relations, “[i]n saying that certain colors, Red and Green for example, are complementaries we must recognize the fact that these colors are variable under their terms or names,” going on to caution that

“[w]e must be careful not to be influenced by the words or names we use and the effects which may be associated in our minds with those words or names. If, thinking of Red as the effect of English Vermillion and of Green as the color of green grass, we produce tones to express these ideas, we shall produce a Red and a Green which will not be complementaries.”<sup>107</sup>

As with English Vermillion and green grass, so with red of “0.612 microns” and green “between wavelengths 0.511 and 0.543 microns.” Even if colors and names could be fixed according to wavelength, it did not therefore follow that colors so defined would combine in a fashion that produced a regular color system.

The second shortcoming of wavelength as a determiner of color identification was that, by the turn of the century, even physicists were beginning to see wavelength as an overly astringent way of defining colors, particularly for the purposes that Munsell required. Shortly after he decided on his five-fold division, Munsell visited Charles R. Cross, then the head of the physics department at MIT, who praised Munsell for “establish[ing] the idea of color based on something fixed.” Cross advised Munsell, however, that his project was really “a matter of psychology

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<sup>107</sup> Ross, *The Painter's Palette*, on pg. 4.

– rather than physics” – that is, more a matter of subjective experience than objective measurement.<sup>108</sup> Cross’s associate at MIT, Henry E. Clifford, was similarly, as Munsell put it, “emphatic that I had better not try to base [the system] on wavelength.”<sup>109</sup> And Amos Dolbeare, chair of the department of Astronomy and Physics at Tufts College told Munsell that “[t]he wavelengths of the physicist are unserviceable for the artist and business man.” “Color,” he declared, “is an *ancestral and racial* experience, not based on the spectrum.”<sup>110</sup> It was not to the spectrometer that Munsell ought to turn, continued Dolbeare, but the experience of the seer: “the eye judges by sensations,” he proclaimed, “and is the ultimate test.” To Munsell’s essential question, then – “shall [the system] be based on spectrum wave-lengths or upon the physiological effect which the wavelengths produce upon the retina?” – the answer was clear. “To the artist,” Munsell wrote, “it must be the latter.”<sup>111</sup>

Defining his main colors according to the “physiological effects” of different wavelengths of light on eye of the observer, however, considerably complicated Munsell’s attempts to map color onto a spherical solid. At least initially, Munsell had considered defining his five principle colors in terms of their maximum “chroma” – that is, in their most vivid manifestations, as the colors appeared in the spectrum. Indeed, Rood advised Munsell in 1901 to set these colors in enamel so as to preserve them, and later that year Munsell recorded in his diary that he was interested in a brilliant aniline green that could be cooked into an enamel so that it wouldn’t

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<sup>108</sup> Diary of Albert H. Munsell, 14 May 1900.

<sup>109</sup> Diary of Albert H. Munsell, 13 Nov. 1900.

<sup>110</sup> Diary of Albert H. Munsell, 27 Nov. 1900. Italics added.

<sup>111</sup> *Ibid.*



fade.<sup>112</sup> Munsell had assumed that the spectral colors would fall uniformly into place across the surface of a sphere because, as he put it in his patent, “[t]here is no other form than a sphere upon the surface of which [a color chart] can be spread” in order to simultaneously define colors mathematically, trace out color harmonies, and present colors as they appeared in nature.<sup>113</sup> Indeed, in a discussion with Jay Hambidge, an art educator and friend of Ross’s who published extensively on the “golden ratio” found both in Greek architecture and in various natural forms, Munsell marveled at the fact that the “ratios in Botany, Choncology [sic] and Crystals” all suggested “Platonic solids [that] inscribe and exscribe a sphere.” Such were the “advantages,” Munsell concluded, “of a circle as a point of departure.”<sup>114</sup> But when he sat down to determine the precise pairs of colors that would produce optical balance when arranged around the equator of his color sphere, it became apparent that the proper shape of color space, as Munsell put it in May of 1901, was “no longer a sphere – but a spheroid.”<sup>115</sup> Using the “coefficients” of different colors – that is, the “length” of the “lever arms” around which colors balanced according to Rood’s simile of mechanical advantage – that he found in *Modern Chromatics* and in *Colour Vision* by British colorimetrist William Abney, Munsell realized that the “chroma,” or intensities of different colors varied dramatically from color to color.<sup>116</sup> The “red” sector of the color solid, which had the greatest extreme of “chroma,” or color intensity, projected twice as far from the center of the sphere as the least

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<sup>112</sup> Diary of Albert H. Munsell, 8 Mar. 1901.

<sup>113</sup> Albert Munsell, 1900, *Color Sphere and Mount*, U.S. Patent no 640, 792, filed 14 Apr. 1899, and issued 9 Jan 1900, on pg. 1.

<sup>114</sup> Diary of Albert H. Munsell, 19 Apr. 1904.

<sup>115</sup> Diary of Albert H. Munsell, 17 May 1901.

<sup>116</sup> William de Wiveleslie Abney, *Colour vision; being the Tyndall lectures delivered in 1894 at the Royal Institute, London* (S. Low, Marston & Company, 1895).

chromatically intense color, a bluish green. Yellow projected nearly as far as red, but its complement, purple blue, did not. The shape of color space was no longer an ideal platonic sphere but rather “an irregular shape, with mountains and valleys, corresponding to the inequalities of pigments.”<sup>117</sup> Munsell recognized that he had put the cart before the horse in specifying the ideal topography of color space before he knew the “facts” of vision.<sup>118</sup> As his friend, B.I. Gilman remarked, the “geographer describes the facts of any country, and the monarch decrees its subdivision and government, but watershed described the flow of water.” To which Munsell – the regent geographer of the color sphere – responded, “[u]ntil the country is mapped and described, how can we subdivide it?”<sup>119</sup>

Its irregular “watershed,” however, did not invalidate Munsell’s color sphere as a practical measure of color space; it simply changed the sphere’s meaning. Within the asymmetrical color solid, Munsell insisted, the symmetrical color sphere still existed, but was obscured by the “enormous mountains” of vivid color that projected from its surface (figure 5.3). If one were to position the lumpy color spheroid “in a turning lathe and tur[n] [it] down until the color maxima are removed, thus producing a color solid no larger than the chroma of its weakest pigment,” Munsell reasoned, one would produce to the original color solid; albeit one which displayed considerably less vivid colors around its equator.<sup>120</sup> These less-vivid colors Munsell called “middle colors” and he made them the central point of his color theory. Rather than concentrating on the bright colors that had attracted

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<sup>117</sup> Munsell, *A Color Notation*, on pg. 52.

<sup>118</sup> Diary of Albert H. Munsell, 17 May 1901.

<sup>119</sup> Diary of Albert H. Munsell, 2 Apr. 1901.

<sup>120</sup> Munsell, *A Color Notation*, 1905, on pg. 73.

other color scientists, Munsell thought of the “middle colors” as the basis of all balanced color sensations, and thereafter thought of the color sphere as a “chromatic tuning fork” – a baseline from which all other sensations could be calculated.<sup>121</sup>

Munsell established his “middle colors” using an intricate arrangement of novel technologies augmented by a great deal of intuition. As he described it in his 1905 *A Color Notation*, the first step of the process was to discern the appropriate mix of complementary colors for each of the ten color categories across the equator of the color sphere. Through trial and error – not to say a profound trust in his own eye as “the ultimate test,” as Dolbeare had said – Munsell first combined different mixtures of colors on a color wheel, attempting to accomplish a neutral gray. For instance, he sensed that the commercial colors “Venetian red” and “Viridian” seemed to provide a good start for a complementary red/blue green, color pair, so he painted each color on a pair of disks, sized to fit on a motorized color wheel. “Having dried these two disks,” he wrote,

One is combined with the other on the motor shaft so that each color occupies half the circles. As soon as the motor starts, the two colors are no longer distinguished, and rapid rotation melds them so perfectly that the eye sees a new color, due to their mixture on the retina. This new color is a reddish gray, showing that the red is more chromatic (*i.e.* its hue is purer and stronger) than the green. But by stopping the motor and sliding the green disk to cover more of the red one, there comes a point where rotation melds

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<sup>121</sup> Munsell, *A Color Notation*, 1905, on pg. 53.

them into a perfectly neutral gray. No hint of either hue remains, and the pair is said to balance.<sup>122</sup>

In this way, Munsell could define the relative chromas of his pairs of colors – that is, their distance from the center of the color solid. In order to insure that the color pair was of “middle” *value* (i.e. midway between the top and bottom of the color solid) as well as of middle “chroma,” Munsell devised a simple photometer (that he later patented and sold for about five dollars) which allowed a viewer simultaneously to view a color sample with an unknown value along side a control plate with a value of 100. Twisting a small dial numbered in 100 degree increments allowed the viewer to slowly open and close a cat’s eye shutter, raising or lowering the value of the control swatch; when the values of swatch and the sample matched – in the judgment of the viewer – the position of the dial would show the numerical measure of the value of the sample according to the Munsell system.<sup>123</sup> Based on this number, the color in question could be lightened or darkened by addition of white or black pigment, then tested again by the photometer. Once the color reached a value of 50%, Munsell then retested it on the color wheel to insure that its chroma hadn’t shifted, and – if all was in order – painted the color on its appropriate spot on the color sphere. The same process could be repeated for colors of different values, until all of the spots on the color sphere were filled.

The “chromatic tuning fork” acted like a three-dimensional color wheel.

Properly calibrated, it could be rotated around any axis and all of the colors on the

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<sup>122</sup> Munsell, *A Color Notation*, 1905, on pg. 47.

<sup>123</sup> Albert Munsell, 1901, *A.H. Munsell Photometer*, U.S. Patent no 686,827, filed 6 Feb. 1901 and issued 19 Nov. 1901.

completed sphere would merge into a uniform gray of varying values. If any one color (or more) stuck out, it meant that the color sphere was unbalanced, and sent Munsell back to his mixing palette to correct the error. Discerning the correct relationship of colors on the sphere was a time-consuming – and hardly ideal – process.

In this, it is worth noting that, during the time in which Munsell worked to solidify the main colors of his color sphere, he corresponded vigorously with Rood, Bradley, and other color researchers about different theoretical aspects of his system; however, curiously enough, he appears not to have been involved in the sort of trade of materials which characterized the practices of other researchers. As indicated by Ridgway and others, trustworthy color materials were in short supply – particularly in the 1880s, but well into the 1900s as well. Peirce, for instance, was delighted to receive a set of “beautiful measuring disks” from Rood, which he used in color notation and matching experiments; in his notes he referred repeatedly to “Rood’s” colors, e.g. “ ‘Rood’s fundamental Blue Violet,’” “Rood’s ‘Staats’ Emerald Green,” and so forth as standards against which to judge his own work.<sup>124</sup> Ridgway similarly corresponded vigorously with Bradley, who apparently freely sent the ornithologist materials and information on color nomenclature.<sup>125</sup> And B. Joy Jeffries, the Boston physician, lent reading material on colors to S. R. Koehler – who

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<sup>124</sup> Charles S. Peirce, 10 June 1886, Notebook: “Color Miscellaneous” 1886-1887, Folder 1016, MS Am 1632, Houghton Library, Harvard University; and Charles S. Peirce, February 1877, Untitled Notebook, Folder 1018, MS Am 1632, Houghton Library, Harvard University.

<sup>125</sup> While Samuel Langley at the Smithsonian Institution was helping Ridgway with his 1912 color nomenclature, Bradley wrote to him with information about color mixing technologies and spectroscopy advice. Thanks to Dan Lewis for this information. See, e.g., Milton Bradley to Samuel Langley, Dec. 13, 1898, RU 31, Box 19, Folder 15, Samuel Langley Papers, Smithsonian Institution Archives, Washington, D.C.

was an expert lithographer at Prang Company – in exchange for Koehler’s help in producing colored disks which Jeffries used in his color blindness experiments.<sup>126</sup> Perhaps because he had an eye on potential patents, copyrights and commercial applications, however, Munsell seems to have been less inclined to undertake this sort of trade. Indeed, in December of 1900, Bradley sent Munsell a sample of his own “middle red” that he was attempting to formulate, and asked for Munsell’s critique. At first, Munsell simply wrote Bradley to say that Bradley’s color was off – Bradley’s sample was composed of part red and part gray, with “values over 40° apart.”<sup>127</sup> Several days later, however, it apparently occurred to Munsell that if Bradley was experimenting with middle colors, that meant the Milton Bradley Company might be attempting to usurp his color theory, and Munsell wrote Bradley a terse note saying, “I object to any use of my color system or experiments – and reserve rights to give it publicity myself at the proper time.”<sup>128</sup> As he formulated his colors, then, Munsell worked in relative material isolation.

If he did not exchange materials with other researchers, however, he did solicit opinions whenever he could on the quality and veracity of his color selections. From what Munsell recorded in his diary, much of the business of setting the precise hue, value and chroma of his “middle” colors involved displaying his attempts at middle colors to his peers, and then arguing them into agreeing that he had selected the correct hues. On May 27, 1901, for instance, Charles Prichard,

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<sup>126</sup> See Benjamin Joy Jeffries to Sylvester Rosa Koehler, 20 18 Feb77; and Jeffries to Koehler, 21 18 Feb77, both in “Benjamin Joy Jeffries, Correspondence, 1877-1891,” Crerar Ms 202, Special Collections Research Center, University of Chicago.

<sup>127</sup> Diary of Albert H. Munsell, 27 Dec. 1900.

<sup>128</sup> Diary of Albert H. Munsell, 2 Jan. 1901.

Munsell's lawyer, examined the color sphere in Munsell's studio and objected that the yellow that Munsell had used was "not the accepted type," calling it "brown" rather than yellow. And indeed, for "middle yellow" Munsell had used a pigment called "raw sienna," which ranged in hue from a mustard to a sort of light shoe-leather color. In response, Munsell fished out his copy of the *Century Dictionary*, where he pointed Prichard to Peirce's definition of brown as "a dark or dusky color leaning towards redness or yellowness" – a clear enough vindication of his color choice, as far as Munsell was concerned. Still, Prichard persisted, Munsell had to "give good reason for displacing [the] popular notion" of yellow – to which Munsell treated Prichard to a comprehensive reiteration of his color theory until Prichard relented, admitting that it was "logical that a middle yellow should unite equal degrees of light and dark."<sup>129</sup> "Middle yellow" thereafter stayed brownish. Rood was similarly critical of the "purple and violet" sections of Munsell's sphere, saying that Munsell's choices were "all off" – though Munsell wrote that, when pressured to do so, Rood accepted the "angular distribution" (i.e. of colors around the sphere) and "cannot say that the colors are misnamed."<sup>130</sup> Again, the colors stayed. For his part, Ross was more stalwart, complaining for years that Munsell's values were "inaccurate," expressing his preferences for a more "purple red" and "find[ing] the yellow-green too dark" – nevertheless, by the end of Munsell's life, Ross appears to have come around to Munsell's sphere, its divisions, and his color choices, and after Munsell's death, Ross published a manuscript embracing some of the tenets of Munsell's system.

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<sup>129</sup> Diary of Albert H. Munsell, 27 May, 1901.

<sup>130</sup> Diary of Albert H. Munsell, 17 May, 1901.

Balance was the core criteria through which Munsell judged the success or failure of his system– the touchstone to which Munsell returned in the face of unanswerable criticism. In September of 1908, for instance, an impromptu summit on the state of the art in American color science commenced on the steamship *Marquette*, aboard which both Munsell and Ladd-Franklin happened to be traveling from Antwerp to Boston. Munsell gave Ladd-Franklin a copy of the new edition of *A Color Notation* (he appears rarely to have traveled without a few) and briefed her on his system; she explained to him the genetic theory of color perception and asked where her four primary colors would be located on his color sphere. Munsell replied that her “first pair [were] not complimentaries (unless the green is bluish or the red purplish) and that they leave out a wide interval of cool color” – thus leaving the circle “unbalanced.”<sup>131</sup> Ladd-Franklin was unimpressed. Similarly, several years later, Robert Yerkes – a psychologist then at Harvard – visited Munsell in his studio, bearing a copy of George Trumbull Ladd and Robert Woodworth’s *Elements of Physiological Psychology*.<sup>132</sup> Yerkes acknowledged the practical benefits of Munsell’s system, but questioned how well it stood up to new paradigms in the psychological and physiological understanding of vision – specifically, the growing recognition among psychologists (as outlined in Ladd and Woodworth) that there were four, rather than three, “stable” colors, and that the retina appeared to be functionally divided into different “zones” of vision; the sensing human was not a “balanced” organism at all, but rather a carefully gerrymandered one. Munsell responded

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<sup>131</sup> Diary of Albert H. Munsell, 24 Sept. 1908.

<sup>132</sup> George Trumbull Ladd was not related to Christine Ladd-Franklin; however Robert Woodworth was her colleague in the department of psychology at Columbia.



simply that his system was “constructed by balance – and whatever disturbs this balance would be called warm or cool excess;” the Munsell system, that is, had been calibrated to provide a neutral sensation, and therefore a neutral sensation was proof of its scientific viability.<sup>133</sup> The color sphere was, in effect, a proof of itself.

This said, for all of his certainty in arguing with others, Munsell did not decide on his final value for “middle red” until 1907, and did not finalize his “chroma scales” until 1912. This did not stop him from beginning to produce material renderings of his color system for commercial markets as early as 1901, though it did complicate his production process. Between 1901 and 1902, for instance, Munsell produced a series of color charts based on his system, employing a “Mr. Lyon” to paint the charts under his supervision. Munsell’s ambition was originally to publish these charts – as well as a manufactured version of the color sphere – with Milton Bradley’s Company; however, Prichard advised him against it, since Bradley was “already a worker in the same line, and had a pet idea.”<sup>134</sup> In 1905, Munsell showed his charts to Arthur Howland, president of Wadsworth and Howland, a printing and pigment supply manufacturer, and the two men contracted to produce a line of Munsell materials – crayons, watercolors, drawing papers and, of course, color spheres. Although Munsell taught Otto Anderson, the shop foreman at Wadsworth and Howland, “how to balance any color with its opposite [...] and so detect leaning to warmth and coolness,” the work of insuring that the colors produced in Wadsworth and Howland’s Malden, Massachusetts factory matched the

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<sup>133</sup> Diary of Albert H. Munsell, 18 Sept. 1911.

<sup>134</sup> Diary of Albert H. Munsell, 2 May 1900.

colors spelled out in his system fell principally to Munsell.<sup>135</sup> After finding that a box of “faulty crayons” had slipped out of the factory undetected, he fumed to the factory manager that “each new batch “must be O.K. by me to save misunderstandings.”<sup>136</sup> At the same time, the need to produce a steady supply of colors occasionally called for cutting corners. On April 20, 1908, Munsell recorded that he tested the “fifth sample of Munsell yellow (worst yet!) [...] I again criticize it as failing to imitate the value hue and chroma of the first enamels.” Three days later, Wadsworth and Howland sent another try at the yellow, which Munsell tested again, then accepted – although, he noted, the color was still too red. “Art may tell small lies,” he reasoned in his diary, “for the sake of a larger truth.”<sup>137</sup> Indeed, it was precisely the “larger truth” of his physically, sensually and morally balanced color system that Munsell hoped to proselytize through the implementation of his color systems in American schools.

#### Colors that Shriek and Swear

On the afternoon of May 16, 1912, in Baltimore Maryland, Munsell presented a lecture on his system for color notation and organization to the annual meeting of the Eastern Art and Manual Training Teacher’s Association. Those who wished to educate the nation’s youth in the principles of vision, Munsell announced, had been laboring for years under a “vague” and inappropriate theory of color – “vicious because it misleads the beginner and vain because it leaves the elements of beauty

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<sup>135</sup> Diary of Albert H. Munsell, 29 May 1911.

<sup>136</sup> Diary of Albert H. Munsell, 11 Mar. 1910.

<sup>137</sup> Diary of Albert H. Munsell, 29 Apr. 1908.

in doubt.”<sup>138</sup> As a corrective, Munsell advertised his own scheme as a “measured color system” based not on “false tradition,” but on the “logical, impersonal and accurate” precepts of science. This system, Munsell instructed his audience, “replaces guesswork by measure, false tradition by demonstrable fact, and creates a clear mental image of all colors with their relations.” With Munsell’s guidance, children could be trained early on in proper modes of vision, replacing the “screaming” yellows, “violent” reds, and “indistinct” blues of conventional education with Munsell’s own carefully calibrated “middle” hues, as determined by rigorous scientific research. But his audience didn’t have to take Munsell’s word for it. As proof of the efficacy of his system, Munsell invited his audience to view a series of pictures “made under ordinary school-room conditions” by elementary school children in Boston who had been taught color the Munsell way. “The samples spread before you,” Munsell proclaimed, “prove that a child trained by moderate degrees of color strength and color light will not flounder about in ugly color, but gradually learn to manage even the strongest pigments with skill.” While the images Munsell presented might seem to the untutored like pictures of a butterfly; a cup; a pair of patterned lozenges in muted blues and greens; a fetching trio of Persian rugs; a mustard-colored canoe with a sea-green outline labeled “Hiawatha,” the assembled teachers saw a powerful statement about the relationship between children’s bodies, children’s minds, and the ways in which human beings learned to understand and experience the world around them.

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<sup>138</sup> Munsell, “Color and an Eye to Discern it,” on pg. 2

As Munsell had witnessed firsthand, the turn of the century in the United States was a period of rapid growth in art education. In 1870, the Massachusetts state legislature passed “An Act Relating to Free Instruction in Drawing,” mandating that administrators should include drawing as “among the branches of learning which are [...] required to be taught in public schools,” and providing that towns with populations of over 10,000 should make available courses in industrial drawing for citizens over fifteen years of age. Practically speaking, drawing education included more than simply instruction in black and white drawing, ranging from instruction in modeling and perspective, to sculpture and three dimensional design, to education in the fundamentals of color use.<sup>139</sup> While advocates of the act could, of course, point to the economical advantages of equipping the rising generation with skills necessary to serve as designers and draughtsman for the burgeoning industrial design, engineering, and commercial art professions, more was at stake than just commercial utility. Advocates of the act emphasized, for instance, that art “cultivated the habits of neatness and accuracy,” and “tended to improve the intellect of the masses, [and] purify the tone of their moral character.”<sup>140</sup> On the heels of the 1870 Drawing Act, other states, particularly in the Northeast, began to include drawing in their state-mandated curricula.

Art was important for the health of the individual and the body politic alike.

In 1873, the U.S. Commissioner of Education wrote that “[w]hoever succeeds in

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<sup>139</sup> On the Drawing Act of 1870 see: Paul E. Bolin, “The Drawing Act of 1870: Industrial Mandate or Democratic Maneuver?” in *Framing the Past: Essays on Art Education*, ed. Donald and Mary Ann Stankiewicz (Reston, Va: National Art Education Association, 1990); and Bolin, “Bordering the Familiar: Drawing Education Legislation in the Northeastern United States, 1871-1876,” *Studies in Art Education*, 45:2, Winter 2004, pp. 101-116. See also Frederick M. Logan, *The Growth of Art in American Schools* (New York: Harper & Brothers, 1955); also Mancini, *Pre-Modernism*.

<sup>140</sup> Quoted in Bolin, “The Massachusetts Drawing Act” on pg. 43.

having all the public school children of the country properly trained in elementary drawing will have done more to advance the manufactures of the country and more to make possible the art culture of the people, than could be accomplished by the establishment of a hundred art museums.” Art, continued the Commissioner, is open to him whose “eye has been trained to see, and his fingers made facile to execute” – however, the relationship between the eye that saw, the fingers that crafted, and the mind that comprehended were open to debate.<sup>141</sup>

This was where, for Munsell, the principle of “balance” embodied in his sphere found its apotheosis. His readings in the psychophysics of color had convinced Munsell that the eye was an organ in a constant state of flux between balance and upset in its color sensing capacities. Each of the retina’s three primary color receptors – red, green and blue – strove to maintain parity with the others. Bright colors could potentially overload these receptors, “fatiguing” the eye, and throwing the whole color sensing apparatus off balance. In a state of nature, such a condition of unbalance was unlikely to occur. The eye had developed in order to apprehend a chromatic environment dominated by “middle” hues, which easily maintained the balance of the ocular system. “Nature, who would seem to be the source of our notions of color harmony,” Munsell wrote in the second (1907) edition of *A Color Notation*, “rarely repeats herself, yet is endlessly balancing inequalities of hue, value, and chroma by compensations of quantity.”<sup>142</sup> True, the natural world might present small surges of intense color – for instance, bright yellow buttercups or red poppies – but, Munsell pointed out, “Their sunlit points give pleasure because

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<sup>141</sup> “Progress of Education,” *New York Times*, 7 Nov. 1874, on pg. 8.

<sup>142</sup> Albert Munsell, *A Color Notation*, 1907, on pg. 60.

they are surrounded and balanced by blue ether and wide green fields. Were these conditions reversed, so that the flowers appeared as little spots of blue or green in great fields of blazing red, orange, and yellow, our pained eyes would be shut in disgust.”<sup>143</sup>

The built environment of the turn of the century, on the other hand, showed no such restraint. If nature provided abundant instances of color balance, for Munsell, the “gaudy chromo and flaming bill-board,” provided the opposite – a state underwritten by a widespread commitment to the red/yellow/blue theory of primaries, in which “the balance of color is rendered impossible.”<sup>144</sup> Misunderstanding the relationships between colors led to a dissonance between mental perception and physical stimulus. This dissonance, in turn, could lead to more than just an unpleasant viewing experience or discomfort in the eyes. “There are color groups,” Munsell wrote, “which, acting through the eye, can convey pleasure or pain to the mind.”<sup>145</sup> He warned his readers, “[t]o range at random in the immense field of color sensations, without plan or definite aim in view, only courts fatigue of the retina and a chaotic state of mind.”<sup>146</sup> Attempting to navigate the modern visual sensorium unaided was bad for one’s health, both physically and mentally. What Munsell was offering was visual prophylaxis: “balance – retinal ease – freedom from strain and fatigue,” he jotted in his notes.<sup>147</sup>

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<sup>143</sup> *Ibid.*

<sup>144</sup> Munsell, *A Color Notation*, 1905, pg. 78.

<sup>145</sup> *Ibid.* on pg. 70.

<sup>146</sup> *Ibid.* on pg. 30.

<sup>147</sup> Diary of Albert H. Munsell, 27 Nov. 1906.

Among the individuals most vulnerable to the mental confusion, and indeed, physical peril, wrought by improper understanding of visual stimulus were children. “*Beginners should avoid Strong Color,*” Munsell insisted, “[e]xtreme red, yellow, and blue are discordant. (They ‘shriek’ and ‘swear.’) Yet there are some who claim that the child craves them, and must have them to produce a thrill. So also does he crave candies, matches, and the carving-knife. Like the blazing bill-board and the circus wagon, they may be suffered out-of-doors; but such boisterous sounds and color sprees are unfit for the school-room.”<sup>148</sup> Although Munsell acknowledged that there might exist the occasional student who instinctively knew to avoid these strong colors before he was ready, he insisted that “systematic discipline of the color sense is necessary for most children.”

Munsell was not alone in this conviction. Early in the development of his system, Munsell courted the opinion of local educators. In June of 1900, Myron Pritchard, schoolmaster of Boston’s Everett School, came to Munsell’s studio. Viewing the system in development, he declared it “a necessity in education,” and the two men discussed the possibility that one could “train [the] color sense, so that children may have not only names – but color values.”<sup>149</sup> Similarly, James Hall, an administrator in the Boston public school system and Henry Bailey, a state official of art education for Massachusetts and editor of the influential *School Arts Book*, visited Munsell’s studio and left convinced that his system “should be in the schools – since the present methods fail to teach harmony or color relations.” Hall, Munsell recorded in his diary, “is enthusiastic and calls [the system] ‘perfect.’ Wants it in

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<sup>148</sup> Munsell, *A Color Notation*, 1905, pp. 60-61.

<sup>149</sup> Diary of Albert H. Munsell, 4 Jun. 1900.

schools as soon as possible.”<sup>150</sup> On the other hand, J.P. Haney – “sometime Lecturer on Physiological Pedagogics” at New York University and Director of Manual Training for New York’s Public Schools – cautioned Munsell in 1905 that “[c]hildren demand the strongest chromas [...] you had better wash your hands of the ways and means of schoolrooms – devoting your attention to the teachers. That is big field in itself.”<sup>151</sup> Haney advised simply giving teachers a rule of thumb about how to use the Munsell system, then allowing them judge its efficacy for themselves. “Theory after practice,” Haney cautioned.

This advice seems to have been unacceptable to Munsell. “Education,” he complained to his audience in Baltimore, “seems unable to take this hint of color balance.”<sup>152</sup> The gaudy colors of “Froebel’s gifts” – the common pedagogical tools for elementary education manufactured, among other places, in Bradley’s Springfield factory – “started the child at his most impressionable age with false notions and a crude disregard of balance.”<sup>153</sup> As an advertisement for the Munsell Color System in the *American School Board Journal* instructed teachers, “Red – Yellow – Blue are not the PRIMARY COLORS. But we have always been taught to believe this. Strong red, yellow and blue pigments are beyond a child’s control. These violent colors set up at the outset a false notion of color relation.”<sup>154</sup> Still, there was hope – the Munsell color system offered the teaching of red, yellow and blue, but in a measured system,

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<sup>150</sup> Diary of Albert H. Munsell, 1 Dec. 1900.

<sup>151</sup> Diary of Albert H. Munsell, 24 May 1905; For Haney’s title see James Parton Haney, “The Education of the Dullard in the Public School,” from *Annals of Gynecology and Pediatrics*, reprint, June, 1906, p 1.

<sup>152</sup> Munsell, “Color and an Eye to Discern it,” on pg. 13.

<sup>153</sup> *Ibid.* on pg. 7

<sup>154</sup> Advertisement: “Munsell Color System,” in *The American School Board Journal*, XLVII: 6, June 1914, on pg. 60.



along with the middle colors, which would teach children appropriate color relations. "These colors," readers of Munsell's advertisement would find, "should be used in the form of crayons, water colors, atlases of charts, sphere, etc." This was, after all, "the only method of teaching color scientifically."<sup>155</sup>

This said, Munsell taunted his audience, "perhaps you reject the verdict of science. You say a colorist is born, not educated, and that any reference to science is a waste of time." He noted that the question, "[w]hat measures underlie the art of pleasing color," was "sometimes met with a blank look of incredulity." But why should this be the case? If pleasing color derived from chromatic harmony, and chromatic harmony from balance, then that balance should in turn be measurable – and if measurable, then those measurements should "be standardized by scientific methods or they will [...] vary from day to day, according to the mental and physical poise of the individual." Now, he chided the assembled teachers, "perhaps you think this too exact and formal as an approach to color study." Indeed, perhaps, "the thought arise[s] that this scientific structure unfits it for a child."<sup>156</sup> Nevertheless, if one considered the training of the other senses, an unscientific approach to color seemed manifestly absurd: "[w]e do not shout in an infant's ear, or give it strong food, or handle it with violence. And, in later education, loud sounds are not the basis of musical training, nor savage feats the door to graceful demeanor."<sup>157</sup> "Only in color does such savagery exist," he concluded to his audience in Baltimore.

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<sup>155</sup> *Ibid.*

<sup>156</sup> Munsell, "Color and an Eye to Discern it," on pg. 7.

<sup>157</sup> *Ibid.*

“Education aims at control of the body and the mind, and it is high time to apply logical methods in the training of the eye.”<sup>158</sup>

The discussion period following the talk yielded decidedly mixed responses. Royal Farnum, a former student of Munsell’s and the Director of Art Education for New York State, could barely contain his enthusiasm. “I am so optimistic about this so-called Munsell color theory,” he declared, “that I feel like the man who went into the restaurant without a cent in his pocket and ordered a dozen blue points and a pint of ale, knowing that he would find a pearl to pay for it at the end.”<sup>159</sup> For Farnum, Munsell’s system offered unprecedented access to a deep, epistemological truth: “I believe we have not taught color, for the simple reason that we have not known it [...] There is no doubt but that a false color theory should give way to a true color theory, and then I feel we will be able to teach it.”<sup>160</sup> Similarly, James Frederick Hopkins, director of the School of Art and Design at the Maryland Institute, lauded Munsell as the living embodiment of a newer, truer, form of perception. “Here is a man who *sees color*,” Hopkins exclaimed, “Wouldn’t you like to study in his studio and say, ‘By Jove! I have done that thing?’”<sup>161</sup> Others, however, were not so certain. R.K. Piez of the Oswego Normal School grumbled that “theory is something which the scientist has ‘put over’ the colorist.” He assured the assembly that “[c]hildren don’t start out with theories and don’t start out with systems” – “children are empiricists, they are not scientists.”<sup>162</sup> For Piez, a child’s first

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<sup>158</sup> *Ibid.* on pg. 13.

<sup>159</sup> *Ibid.* on pg. 16.

<sup>160</sup> *Ibid.* on pg. 17.

<sup>161</sup> *Ibid.* on pg. 24.

<sup>162</sup> *Ibid.* on pg. 19.

imperative was to learn about the stuff of color – about pigment, and how pigment applied to paper, how mixing different pigments made different colors. From this activity, children could eventually come to learn different theories of color, but these theories did not precede practice. Indeed, Piez was skeptical about the injurious effects of bright colors on young eyes: “I don’t find that [children] reject the violent colors or are in any way tainted by them; I don’t find that they are in any way injured by them.”<sup>163</sup> As for training the eye, Piez remarked that “the eye is just an optical instrument, and we might as well talk about developing the lenses from the microscope as developing the eye.”<sup>164</sup> For Piez, Munsell’s proposal represented a flawed assessment of child cognition and children’s physiology. Langdon Thompson, a drawing teacher from New Jersey, quibbled with some of Piez’s general concerns about induction versus deduction – “the work of any mind must be practical,” he agreed; nevertheless, “we must begin to form some sort of order and arrangement (which is nothing more than theory) when we begin to practice.”<sup>165</sup> As concerned Munsell’s system in general, however, Thompson indicated that such concerns were academic, since he refused to accept either the system’s practical utility or its theoretical validity. And for her part, though Emma Church, principal of the normal school at the Chicago Academy of Fine Art, felt that Munsell’s system was assuredly “scientifically color true,” she questioned whether his precisely defined color relations would truly allow the development of fine and even affective

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<sup>163</sup> *Ibid.* on pp. 19-20.

<sup>164</sup> *Ibid.* on pg. 20.

<sup>165</sup> *Ibid.* on pg. 23.

relationships with color. Was not the human experience of color sensations inherently, even advantageously, fluid and vague?<sup>166</sup>

In spite of the aspersions that Munsell cast on their commitment to science, that is, for his interlocutors in Baltimore the problem wasn't with science *per se*. True, some educators in the United States certainly sided with the architecture critic Russell Sturgis, who had written to the president of venerable Columbia University in 1902 urging that "a manual art has nothing to do with the thoughts which are expressible in words; by it [i.e. art] thoughts are expressed wholly otherwise." Indeed, for Sturgis, any art education, scientific or otherwise, could do "nothing but injury" to the careers of budding artists.<sup>167</sup> But among the educators who were unsure about Munsell's color theory in Baltimore, anyway, science was an integral part of education – not to be banished or distrusted, but rather to be leveraged for better education, better students, and (in turn) a better society. Church's mission at the Chicago normal school, after all, was to "acquaint [prospective teachers] with the principles of scientific education" among which included not only "principles of design, composition and color, [and] applied design" but also " physiology [and] psychology."<sup>168</sup>

The question with which these educators struggled then, was how Munsell's theoretical model – even if realized in material form – gived not only with physiology and psychology, but also with *children's* physiology and psychology. Even

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<sup>166</sup> *Ibid.* on pg. 23.

<sup>167</sup> Russell Sturgis, "The Study of Art: Its Proper Place in a University Course," *New York Times*, July 5, 1902, BR15.

<sup>168</sup> James Haney, ed. *Art Education in the Public Schools of the United States: a symposium prepared under the auspices of the American committee of the third international congress for the development of drawing and art teaching, London, August, 1908* (New York: American Art Annual Incorporated, 1908).

as Munsell was developing his system, Thompson had written in 1896 that the challenge of education was to get “the rising generation to know right, to feel right, and to do right” – a collusion of knowledge, sensation and morality which could only come from systematic study which was attentive to the biological facts of human development. “It seems to be agreed,” wrote Thompson, “that the child, at least in a general way, passes through the same stages of evolution that the race passed through.”<sup>169</sup>

This argument was echoed in various instantiation throughout the twentieth century by the child study movement introduced by G. Stanley Hall, which emphasized, among other things, that models of education such as Munsell’s, which exposed children to abstract reasoning early on, were not, in fact, scientifically astute ways of prosecuting education. For Hall and his followers, children’s apprehension of the world around them stemmed directly from their physical development, which itself recapitulated the social and evolutionary development of human beings. This, in turn, insinuated that the best pedagogical strategy was to let the child’s interest guide the way in choice of educational topics – lest one stanch the child’s evolutionary development towards becoming a proper, modern, member of society. As Frederick Burk, one of Hall’s followers, noted, “the child who is most the child, as a child, will be most the man, as a man.”<sup>170</sup> Children were unprepared

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<sup>169</sup> Langdon Thompson, “Art in the Schoolroom, Through Decoration and Works of Art,” in *Journal of Proceedings and Addresses of the Thirty-Fifth Annual Meeting of the National Education Association*, (Chicago: University of Chicago Press, 1896).

<sup>170</sup> Frederick Burk, “The Genetic Versus the Logical Order in Drawing,” in G. Stanley Hall, ed., *The Pedagogical Seminary*, Vol IX, 1902, 296 – 323, on pg. 321.

and uninterested in thinking about questions of color and language until much later than Munsell proposed.

Hall and his followers pronounced on a variety of subjects, from the proper teaching of geography to the development of instincts of love and home. For art educators, the recapitulation of “primitive” forms of development offered a path to understanding the ways in which children’s sensations and perceptions changed over time. In his 1902 article, “The Genetic versus the Logical Order in Drawing,” for instance, Burk—president of the State Normal School in San Francisco – argued that art education should be firmly grounded in the evolutionary physicality of the student. “Dispositions,” wrote Burk, “tempers, traits of character, instincts, emotions, love, music, art, faith, and even the religious impulses, whose roots perhaps reach back into countless ranks of ancestry are nonetheless indications of physiological states of the organism at a given moment.”<sup>171</sup> As such, education ought to follow the “genetic” interest of the child, rather than “logical” order imposed by adults. Children didn’t naturally want to start drawing by using simple geometric shapes because of “interest shown to be generic and deeply rooted in hereditary tendencies in all probability.”<sup>172</sup> Children preferred pre-linguistic, pre-logical – indeed, pre-historic – forms of mark making such as scribbling, or enacting non-representational or performative scenes on paper (drawing a bird, for instance, as a

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<sup>171</sup> Burk, “Genetic Versus Logical,” on pp. 307-308. Indeed, Burk was so aggressively corporeal that even when moved to class certain habits of drawing as “psychological” he immediately qualifies his categorization, noting that these inaccuracies, “may be classified as psychological, not, however, with the implication that they have no physiologically causal dependence” (316). Thompson would have been aware of Burk’s work, if not through general interest then through a 1908 art educator’s conference in England in which he was on the co-operating committee. See Haney, *Art Education*, pg. 109.

<sup>172</sup> Burk, “Genetic Versus Logical,” on pg. 307.

line, such that the act of drawing the line symbolized the bird's flight). And they should be allowed to pursue these endeavors, Burk argued, lest attempts to stifle such efforts adversely affect "health and preservation," and cause "injury to immature forms of development."<sup>173</sup> Writing specifically on color sensation a decade later, Amy Eliza Tanner hewed to a similar line of reasoning: "[i]n [his/her appreciation of color] the child follows, in the main, the race development: bright or gaudy colors before delicate ones, and the utilitarian value of objects before the aesthetic."<sup>174</sup>

For those in Munsell's audience in 1912 who were uncomfortable with his system, then, the problem was not that Munsell's system was too scientific. Rather, he had incorrectly apprehended the subject of his science. It is true that, following Dolbeare, Munsell had considered the "ancestral and racial" development of the color sense – and had gone looking for it in the physicality of the viewer. And in Munsell's conviction that human vision was calibrated to view the natural world and not one of garish billboards and electric signs one can perhaps glimpse a commitment to a prelapsarian vision of aesthetic and biological harmony. But in literally crystallizing color in the form of his solid – and instructing that, by this solid, children should learn the rules of perception – Munsell had failed to appreciate the ways in which biology, physiology, and aesthetics were all interlinked, on a deep level, with history. In order to reach their full development, children – and the objects with which they interacted – *had* to be allowed to shriek

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<sup>173</sup> Burk, "Genetic Versus Logical," on pg. 306.

<sup>174</sup> Amy Eliza Tanner, *The Child: His Thinking, Feeling and Doing* (New York: Rand McNally, 1904) on pg. 469.

(if not swear). Under Munsell's system, some teachers complained, students could not even paint "buttercups in the first three grades."<sup>175</sup> As such, the problem was not, as Munsell had put it, that color education was characterized by savagery. In fact, it was precisely the reverse. In putting theory before sensation – in attempting to cultivate an image in children's minds of "measured" color sensations before children even knew what to measure, Munsell's system did not allow savagery enough.

Munsell left Baltimore after his talk on a 5:00 train, evidently pleased with his presentation. In subsequent weeks he was preoccupied with administrative matters. He was about to release a new "color atlas" – a definitive guide to his color system, with each alphanumeric designation attached to a particular shade; he had recently been informed that a law passed in 1896 potentially invalidated his claim to royalties accrued from Massachusetts schools' purchases of Munsell items because of his position at the MNAS; a steady trickle of curious teachers and school administrators filtered through his studio. At the same time, Bailey – initially receptive to his system had, in 1909, turned hostile, claiming that Munsell "was wrong in assuming that a child's brain is already developed to a point where it is susceptible to subtle color" – an argument which Munsell dismissed out of hand, writing Bailey that, "to put yourself in touch with progress – you certainly need to heed my friendly warning [i.e. to accept the Munsell system]."<sup>176</sup> Bailey did not heed Munsell's warning, and in 1912 penned a sharply worded editorial urging a "return

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<sup>175</sup> Diary of Albert H. Munsell, 15 Mar. 1909.

<sup>176</sup> Diary of Albert H. Munsell, 20 Sept. 1909.



to strong color.”<sup>177</sup> The next year Bailey was back at Munsell’s studio. Evidently Munsell’s talk had convinced influential people within the Eastern Arts and Manual Training Teacher’s Association, because Bailey said he was willing to vouch for the Munsell system in the *School Arts Book* since it was widely accepted by their membership. But his recommendation came with a word of admonishment. “[Bailey] [t]hinks I have acted as if I only was right, and all others are wrong,” noted Munsell in his journal, and “have not treated him or Sergeant or Daniels as if they knew anything about the subject [of color]; but he will not let me treat him so.” This said, Munsell noted that Bailey had “never doubted that I was scientifically right – and had established the standard – but had not adapted it to long established habits of color thought.”<sup>178</sup>

#### Conclusion: Blood, Steel and Meat

At the height of his influence, Munsell’s System – as conveyed through Munsell crayons, Munsell spheres, Munsell watercolors, and Munsell’s program of art education as Munsell explained it in *A Color Notation* – reached classrooms across the United States and Europe. By 1909, a number of public grade schools in Massachusetts – including those in Boston, Cambridge, Somerville, Revere, Everett, Clinton, Marblehead, and Brockton – had adopted the system; in Rhode Island, schools in Bristol and Warren taught Munsell’s system; and further south, Munsell recorded a school in Naugatuck, Connecticut using his scheme to teach colors.<sup>179</sup> As

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<sup>177</sup> Diary of Albert H. Munsell, 30 Oct. 1912.

<sup>178</sup> Diary of Albert H. Munsell, 7 Mar. 1913.

<sup>179</sup> Diary of Albert H. Munsell, 15 Mar. 1909.

Director of Art Education for New York, Munsell's student, Royal Farnum pressed successfully for the Munsell system's use art classes in New York City public high schools, while private New York schools such as the Ethical Culture school also taught color the Munsell way. In higher education, normal schools in Salem, Westfield, North Adams, and Bridgewater in Massachusetts, and Columbia Teachers' College in New York all made use of the system; Farnum followed up his work in New York by instituting the Munsell system at the Rhode Island School of Design when he became its Education Director, and later Executive Vice President, in 1929. Further afield, in May of 1907, a "Miss Amy Roberts," Superintendent of Art in Minneapolis schools, visited Munsell's studio and left with a pledge to "take [the system] up with High School teachers,"<sup>180</sup> while further afield still an administrator from a "High School of Drawing" in Munich wrote Munsell to say that he planned to introduce Munsell's system into his school's curriculum in the fall of 1910. Indeed, an even higher authority than public school administrators may have vetted Munsell's system: in 1909 Munsell made note of an article in a Pittsburg newspaper about "a lecture on the Munsell color system given at the meeting of the Bible Class of the First Methodist Episcopal church Sunday School" in Pittsburg, Pennsylvania – though he did not give any hint as to the content of the lecture.<sup>181</sup>

Two years after his talk in Baltimore, Munsell became ill on a trip to London and remained thereafter in uncertain health, which limited his ability to oversee the manufacture of Munsell color products. Perhaps because of his attenuated involvement in the process, by 1918 Munsell had grown dissatisfied with

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<sup>180</sup> Diary of Albert H. Munsell, 15 May 1907.

<sup>181</sup> Diary of Albert H. Munsell, article from the *Corapolio Record*, 11 Feb. 1909.

Wadsworth and Howland's handling of his color materials, and, in an acrimonious meeting that February, accused Howland of an "unfair attitude toward [his] system." Howland protested that he believed in the "scientific nature of [Munsell's] work," but Munsell insisted that Howland "ignore[d] the fundamental law of sensation" as he worked with Munsell's colors.<sup>182</sup> As a result of his growing distrust of Howland, on February 6, 1918, Munsell filed papers with the Massachusetts State House in Boston establishing the Munsell Color Company; he died several months later, on July 28, 1918. Although in his last years his failing health convinced Munsell that he was "not expected to survive" much longer, the Munsell Color Company insured that his vision – as literally captured in the form of color spheres, charts, crayons and color atlases – would outlast him in the legal person of his company.

After his death, the influence of the Munsell system in schools faded for a variety of reasons. Historian of color Faber Birren writes that the decline of the Munsell system as an educational tool was due the growing influence in art of "abstractionists and action painters" who "abandoned formal training and cast off all restrictions" in the American art milieu following World War II.<sup>183</sup> But Birren's explanation is unsatisfying for a number of reasons. For one thing, Munsell's system was in decline in grammar schools well before the "abstractionists and action painters" were in a position to shove it aside, having hit its zenith during the 1920s. Secondly, while it is true that during the 1920s and 1930s a growing resistance to what John Dewey called "emphasis on routine and mechanical habit" in art

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<sup>182</sup> Diary of Albert H. Munsell, 13 Feb. 1918.

<sup>183</sup> Faber Birren, "Introduction," in A.H. Munsell, *A Color Grammar* (New York: Von Nostrand and Reinhold, 1969) on pg. 5.

education made color study of the sort advocated by Munsell seem déclassé, there is little evidence that Munsell's system in particular was targeted for criticism.<sup>184</sup> True, Dewey's disciple, Philadelphia art collector Alfred C. Barnes, heaped abuse upon Munsell's colleagues Hambidge and Ross, but Munsell escaped unscathed – indicating either that Munsell's system was already in decline, and therefore not worth the parting shot, or perhaps that Munsell's theories of color pedagogy managed to conform to the “discoveries [...] in the field of esthetics, psychology and scientific method” that Dewey, Barnes, and like-minded scholars lauded.<sup>185</sup> Finally, while Munsell was, indeed, an exponent of “formal training” in art – and his system was a formalism in the most literal sense of the word – as art historian Caroline Jones has pointed out, the work of “abstractionists and action painters” was hardly a rejection of formalism or formal training. Rather, it could be understood – for instance, by critics such as Clement Greenberg – as a means of attempting to organize and regulate the feelings bourn by the sensing (modern) body, as understood not least of all through science.<sup>186</sup> As such, it is difficult to accept the idea that Munsell's system – in all of its semiotic density – was simply unable to weather a gestalt change in art education.

A more plausible explanation can be found in an early history of the Munsell Color Company penned by Dorothy Nickerson, one of its first employees, who went on to become an accomplished scientist with the USDA. In 1921, Munsell's son,

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<sup>184</sup> John Dewey, “Forward” in *Art And Education*, ed. John Dewey (Merion, PA: Barnes Foundation Press, 1969:1929) pp. 2- 8; on pg. 2

<sup>185</sup> Alfred C. Barnes, “Sabotage of Public Education in Philadelphia,” in *Art And Education*, ed. John Dewey (Merion, PA: Barnes Foundation Press, 1969:1929), pp. 270 – 276, on pg. 274.

<sup>186</sup> Caroline Jones, *Eyesight Alone: Clement Greenberg's Modernism and the Bureaucratization of the Senses* (Chicago: University of Chicago Press, 2005) esp. pp. –51-96.

Arthur Ector Orr (A.E.O.) Munsell took over presidency of the Munsell Color Company. As Nickerson remembered, “the burden of handling the details of a school supply business irked [A.E.O.] Munsell. There were no profits, so there was little interest and incentive for keeping on a business manager.”<sup>187</sup> In 1923 A.E.O. Munsell divested the company of its educational division, selling the production of Munsell crayons to Binney and Smith Company – whose “Crayola” line was becoming quite popular – and the production of all other educational materials such as watercolors, drawing paper, and pencils to Favor, Ruhl and Company.<sup>188</sup> Without the strong commitment of the elder Munsell to formal color pedagogy in primary schools, Munsell’s color system in education slowly faded – although as late as the mid 1960s it was still possible to learn the Munsell system in outposts such as the Rhode Island School of Design.

What A.E.O. Munsell lacked in his commitment to color education, however, he made up for in his interest in promoting the Munsell color system as an industrial and scientific standard, particularly through strategic partnerships with the National Bureau of Standards (NBS). Created by order of congress in 1901, the NBS was a federal agency charged with comparing, constructing, testing, calibrating and safeguarding “the standards used in scientific engineering, manufacturing, commerce, and educational institutions.”<sup>189</sup> Since 1838, the Office of Weights and Measures – a division of the Treasury Department – had supplied standards for commonly used units of measurement such as the kilogram and the meter, but the

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<sup>187</sup> Dorothy Nickerson, “History of the Munsell Color System and Its Scientific Application,” *Journal of the Optical Society of America*, Vol. 30, Dec. 1940, pp. 580 – 586, on pg. 580.

<sup>188</sup> Nickerson, “History of the Munsell Color System,” on pg. 580.

<sup>189</sup> Act of March 3, 1901, 15 U.S.C. 271-278h, 1901.

Office was woefully understaffed and principally served as a satellite to the U.S. Coastal Survey (of which sometimes-color scientist Peirce was a famously scandal-laden employee).<sup>190</sup> In 1897, Henry S. Pritchett – then head of the Coastal Survey, before he departed in 1900 to assume the presidency of MIT – hired Samuel Wesley Stratton to oversee the Office of Weights and Measures, with a mandate to report on the Office’s “work and efficiency [...] and to recommend, if it seemed advisable, a plan for its enlargement into a more efficient bureau of standards, which might perform for [the United States] the work carried on by the Reichsanstalt in Germany.”<sup>191</sup> Stratton engaged his job vigorously, and within a year produced a plan for the NBS, which secured congressional approval two years latter. As Lyman Gage, then Theodore Roosevelt’s Secretary of the Treasury put it, the question of a National Bureau of Standards was not simply a practical one, but a “moral” one as well. “We are the victims of looseness in our methods,” he told congress, “of too much looseness in our Ideas; of too much of that sort of spirit, born out of our rapid development, perhaps, of a disregard or a lack of comprehension of the binding sanction of accuracy in every relation of life.”<sup>192</sup> It was exactly this sort of “looseness” – in everyday color perception and notation, anyway – that the Munsell system had

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<sup>190</sup> The standard history of the NBS can be found in Rexmond C. Cochrane, *Measures for Progress; a History of the National Bureau of Standards* (Washington, D.C.: National Bureau of Standards, 1966). See also “The Proposed National Standards Bureau,” *Science*, 12: 298, 14 Sept. 1900, pg. 412; “The National Bureau of Standards,” *Science*, 13:325, 22 Mar. 1901, pp. 474-475; Henry S. Pritchett, “The Story of the Establishment of the National Bureau of Standards,” *Science*, 15:373, 21 Feb. 1902 pp. 281 -284, on pg. 282; P. H. Bates, “Work of the National Bureau of Standards on Industrial Materials,” *The Scientific Monthly*, 37:2, Aug. 1933, pp. 174-181; George K. Burgess, “The National Bureau of Standards,” *The Scientific Monthly*, 36:3, Mar. 1933, pp. 200-212; Thomas C. Lassman, “Government Science in Postwar America: Henry A. Wallace, Edward U. Condon, and the Transformation of the National Bureau of Standards, 1945–1951,” *Isis*, 96: 1, Mar. 2005, pp. 25-51.

<sup>191</sup> Pritchett, “The Story of the Establishment of the National Bureau of Standards,” on pg. 282

<sup>192</sup> Lyman Gage quoted in David Noble, *America by Design: Science, Technology, and the Rise of Corporate Capitalism* (New York: Oxford University Press, 1977) on pg. 75.

originally been crafted to counteract.

Stratton appears not to have considered color to be a pressing concern, however, at least in the early days of the NBS. Although the bureau had an optical division, it was principally dealt with *photometry*, that is, the measure of light of any hue; *polarimetry*, the measurement of polarized light, useful for testing sugar purity; *radiometry*, or the discernment of “laws and constants” of electromagnetic radiation; *spectroscopy*, the measurement of spectral lines for chemical analysis; and *pyrometry*, the measurement of temperature as a function of electromagnetic radiation.<sup>193</sup> Questions of color appearance – much less how human beings apprehended color – were not on the agenda of the early NBS.

Indeed, of these sections of the optical division, pyrometry in particular could be seen as actively displacing a certain sort of color sensitivity: the Bureau’s interest in pyrometry had its basis in steel manufacture, in which different temperatures of steel were known among experienced workers to glow with different colors, from red, to orange, to yellow to white. As historian Thomas Misa writes, “[b]y judging the color of a particular heat – for example, “bright cherry” – blacksmiths could accurately reproduce it.” That is, Misa clarifies, “a particular color did not *represent* an analytic qualitative temperature. Rather a color *was* the heat at which a blacksmith preformed a particular operation, such as bending, forging, welding, or heat treating.”<sup>194</sup> Galvanized by the work of Frederick W. Taylor – who, before he published the *Principles of Scientific Management* (1914), worked on standardizing

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<sup>193</sup> E.C. Crittenden, “Early Work in Applied Optics at the National Bureau of Standards,” *Journal of the Optical Society of America*, 41:6, Jun. 1951, pp. 369-376, on pp. 371-374.

<sup>194</sup> Thomas J. Misa, *A Nation of Steel: The Making of Modern America, 1865-1925* (Baltimore: Johns Hopkins Press) on pg. 190.

the color temperatures of steel – Stratton devoted the resources of the NBS to “such pyrometric problems as are of technical and scientific interest,” steel foremost among them. Under Stratton’s influence – buoyed by work by Taylor, Columbia College metallurgist Henry Howe, and others – the NBS transformed the thermal colors of steel as qualitatively judged by steelworkers into standard steel temperatures. Or, as Misa puts it, “the *heat* ‘light cherry’ became the *temperature* 845 °C, or 1,553 °F.”<sup>195</sup> Thus a specialized sort of experiential color perception fell to a specialized tool for temperature measurement.<sup>196</sup>

The elder Munsell was not unaware of developments at the NBS. Little more than a month after the Bureau officially passed congressional writ, Munsell wrote to Stratton asking about Stratton’s plans for the standardization of colors. Munsell didn’t record Stratton’s response, but it was a decade before he tried again. In the interim, he met with Edward Filene, owner of a prosperous chain of department stores, who told Munsell that “retailers want a standard [color] system fixed at all times” in order to estimate the fading of garments and to insure that buyers got exactly the colors they wanted; Filene broached the subject with Munsell again in 1902 when the two met at the Boston branch of the Century Club.<sup>197</sup> Similarly, in 1910, a gentleman from F.W. Taylor’s “firm of Taylor & Co. ‘standardizers of business’” paid Munsell a visit, having read *A Color Notation* with great interest;

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<sup>195</sup> Misa, *A Nation of Steel*, on pg. 191.

<sup>196</sup> On colors temperatures of steel see also M. White and F.W. Taylor, “Colors of Heated Steel Corresponding to Different Degrees of Temperatures,” *Metallographist*, 3, 1900; H.C. Campbell, “The Open Hearth Process,” *Transactions of the AIME*, 22, 1893, on pg. 692; Henry Howe, “The Color-Names for High Temperatures,” *Metallographist*, 3, 1900, pp. 44-46; also C.W. Waidner, “Methods of Pyrometry,” *Iron and Steel Magazine*, 8, 1900, pp. 539-545, James McIntyre Camp, Charles Blaine Francis, *The Making, Shaping and Treating of Steel*, Pittsburgh: Carnegie Steel Company, 1920, on pp. 556-557.

<sup>197</sup> Diary of Albert H. Munsell, 11 Apr. 1901 and 26 Apr. 1902.



Munsell made an appointment to talk with the man's superior but did not record whether the meeting came to fruition. Indeed, Munsell seems to have kept abreast of Stratton and Howe's work in steel; in a May 1911 entry in his notebook, Munsell listed the color stages of "the tempering of steel" – "very pale yellow, straw yellow, brown yellow, light purple, dark purple, clear blue, pale blue, blue tinged with green" beside a sketch of the hue plane of his color solid with an arrow depicting the direction in which the color sequence progressed – though it is not clear whether he viewed his system as a potential industrial standard, or the heating and cooling of steel as a proof of his system.<sup>198</sup> In 1910, the elder Munsell attempted again to open a relationship with the NBS, having sent the Bureau six Munsell color swatches to test as standards (perhaps in an attempt to promote them for national use). In 1911, he visited the Bureau on a trip to Washington D.C., met the chief of the optical division, Perley Gilman Nutting, and left a Munsell photometer for him to experiment with. These efforts seem to have yielded little interest, however.

By the time A.E.O. Munsell took the helm of the Munsell Color Company, however, the Bureau had started to take color investigation more seriously, not least of all because of the 1909 invention of hydrogenation – a technology which, by enabling naturally yellowish vegetable oils to be rendered solid, subverted laws that prohibited the addition of artificial colorants to margarine to make it look more like dairy butter.<sup>199</sup> Enraged dairy producers approached the NBS to draw up stringent standards on the "actual" color of butter, and upon the heels of these investigations,

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<sup>198</sup> Diary of Albert H. Munsell, May 3, 1911.

<sup>199</sup> Ruth Dupré, "'If It's Yellow, It Must be Butter': Margarine Regulation in North America Since 1886," *The Journal of Economic History*, 59: 2, Jun. 1999, pp. 353-371; also W. T. Mickle, "Margarine Legislation," *Journal of Farm Economics*, 23:3, Aug. 1941, pp. 567-583.

other industries became similarly interested in the viability of standard colors, and looked to the NBS for assistance.<sup>200</sup> In 1914, Stratton appeared before congress to request “seventy five hundred dollars” for “developing color standards.” “The passage of certain laws in the States,” he explained, “regarding the coloring of butter, [and] the fact that cottonseed oil and turpentine and other products are sold in accordance with the grade by color, makes it necessary to establish color standards and methods of making them.”<sup>201</sup> In addition, Stratton went on, the “dying trades” had been pressuring the Bureau for color standards, as had the “textile factories, the printing ink trades” – even the “tobacco men” wanted standard colors to make sure that the wrappers for a given brand of cigar remained the same color year after year, and didn’t drift because of previous years’ samples fading. Nutting, explained Stratton, was proficient in this sort of work, but he was tied up investigating the color complaints of the dairy industry. Besides, Stratton noted, the blocks of colored glass that the cottonseed oil men had been using to keep track of the color of their product were not only inaccurate; they were made in Britain – putting the point on the critical importance of funding American color research.

The timing was right to maneuver the Munsell Color Company into the color standards business, and A.E.O. Munsell came up with an effective strategy for doing so. Having divested his company of educational interests, in 1924, the younger Munsell, who – as Nickerson notes – “was more interested in science than in

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<sup>200</sup> Crittenden, “Early Work in Applied Optics,” on pg. 375.

<sup>201</sup> United States Senate, Statements before the Subcommittee of the Committee on Appropriations on H.R. 10523: An Act Making Appropriations to Provide for the Expenses of the Government, of the District of Columbia for the Fiscal Year Ending June 30, 1915, and for Other Purposes, Washington: Government Printing Office, 1915, on pg. 61.

business or education” – founded the Munsell Research Laboratory and moved the company to Baltimore to be closer to Johns Hopkins University and the NBS. While the Munsell Color Company devoted itself to maintaining Munsell’s standard papers and charts – the color sphere having been abandoned as part of Munsell’s educational enterprise – the Munsell Research Laboratory served essentially as a funding arm for color science, providing grants for scientists at the National Bureau of Standards to execute research projects; not least of all those involving Munsell’s colors, such as the “Report on the Spectral Reflectance of 70 representative colored cards from the Munsell color system.”<sup>202</sup> Moreover, in addition to funds and materials, the Munsell Research Laboratory and the NBS shared personnel: Irwin Priest, the NBS’s director of colorimetry following Nutting, advised A.E.O. Munsell on the setup of the Munsell Research Laboratory; Deane B. Judd, a physicist originally in the employ of the Munsell Color Company, left in 1927 to work for the NBS – and subsequently served as a trustee of the Munsell Foundation; while Nickerson, who originally worked as A.E.O. Munsell’s assistant, went on to work at the U.S. Department of Agriculture setting color standards for hay and meat.<sup>203</sup> These material and intellectual trades in turn fed back into the Munsell system’s acceptance as both a government and industrial standard. As Nickerson notes,

[t]he Munsell company, particularly during the period of research activity, had developed a certain amount of consulting business, chiefly in relation to the preparation of standard colors. Thus there were prepared the Flagg-

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<sup>202</sup> Nickerson, “History of the Munsell Color System,” on pg. 582.

<sup>203</sup> Dorothy Nickerson, “History of the Munsell Color System, Company, and Foundation. II: its Scientific Application,” *Color Research and Application*, 1:2, Summer 1975, pp. 69 – 77, on pg. 76.

haemoglobinometer, and the meat-grading scales for the Department of Agriculture [...] the preparation of a color chart for use in advisory work by the Clothing Information Bureau of the Filene Company in Boston [...] standards for soap colors, for scales to measure detergent power, to measure smoke deposits – all such problems, and many more, were handled during the 1921-1930 period.<sup>204</sup>

Similarly, Eugene C. Crittenden, a “physical standards expert” at the NBS, remembered the colorimetric work on the Munsell system as among the most “important” of the Bureau’s “studies [...] on systems of nomenclature and classification of colors.”<sup>205</sup>

In a sense, then, Bailey was right: Munsell’s attempt to train the eyes of Americans was not “adapted [...] to long established habits of color thought.” Indeed, this was precisely the advantage of Munsell’s system. Rather than drafting a system that undertook homology with long-established systems of color notation – from wavelength-based systems such as Bradley’s, to object-based systems such as Ridgway’s, to ideal systems such as those posed by a long line of color-solid predecessors – Munsell’s system was well adapted to *new* ways of thinking about color: not least of all the notion that color perception and the perceptual malleability of the human organism was a matter in need of profound attention from public

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<sup>204</sup> Nickerson, “History of the Munsell Color System, Company, and Foundation. II: its Scientific Application,” on pg. 75.

<sup>205</sup> Crittenden, “Early Work in Applied Optics at the National Bureau of Standards,” on pg. 375; see also W.R. Brode, “E.C. Crittenden: Physical Standards Expert,” *Science*, 124: 3215, 10 Aug. 1956, pp. 255-256.

education, government, and industry. Munsell's system was not, that is, compatible either with the idea of color as an objective quality that Rood had worked hard to reconcile with the religious establishment of late nineteenth century science; nor was it consonant with the notion of color as an absolutely subjective experience. Rather it was compatible with notions of color as a perceptual talent that *ought* to be regulated, *ought* to be standardized, and *ought to* – and indeed *could be* – controlled, through programs of aggressive pedagogy and policing. If disagreements arose over the precise nature of these perceptual policies, their needfulness ceased increasingly to be challenged as the first decade of the twentieth century gave way to its successors. This was the “significance” of Munsell color chips: they were physical instantiations of the promise of modern society to render harmonious not simply aesthetics, but law, production and the body itself for Americans at the beginning of the twentieth century.

## 6

### **Conclusion Still Talking about Color**

In 1879, Rood's attempt to write scientifically about matters of art and aesthetics in *Modern Chromatics* raised eyebrows among his peers. Whether they approved of the physicist's fusion of science and aesthetics or were scandalized by it, the sense was that Rood had set foot upon *terra incognita*, claiming turf for professional scientists that had – at least for the past century – been properly the purview of artists, critics, and philosophers.

More than a century later, in a 2007 response to an editorial entitled “Light and Color: Some Ethical Issues” in *Color Research and Application* magazine, John Hutchings penned an impassioned letter to his fellow color scientists. The use of color in architecture and design, he wrote, could be either harmful or helpful – by “enhanc[ing] negative emotions” in the former case, or by “promot[ing] the civilization of the human race” in the latter – and it was the duty of those who worked with color to insure that visual stimulus was wielded for the good of all. Hutchins closed his editorial with an urgent call for “artists and designers” to join the discussion. “Such a subject” as ethics in color, he wrote, “surely cannot be left only to the scientist” – a reversal of Rood's situation that underscores the centrality

of science as an epistemological framework for understanding color and aesthetics a more than a century after *Modern Chromatics*.<sup>1</sup>

Both the fact that Hutchings could blithely claim for color scientists the task of arbitrating good and bad in color work (and, indeed, that he felt the need to *invite* artists back into the fold), and the fact that there is a disciplinary field of color science at all are reflections of the deep impact of nineteenth century color research in modern America. Indeed, the terms with which Hutchings described the mission of his field – “promoting civilization” in the face of “negative emotions” – could as easily have been penned by Rood, Munsell, Peirce, Woodworth, Ladd-Franklin or any of their peers in color research between 1879 and 1930. For these individuals, color was not simply a uniform phenomenon of the objective world, nor was it merely a property to be leveraged for commercial production. Rather, the ways in which their fellow citizens saw color – and the ways in which science could be used to understand how people saw color – were mutable, uncertain, and central to the construction of a modern American society. Learning to talk about colors was part and parcel with learning to see. And in their attempts to measure, define, describe and encode color perception, scientists, doctors, educators, and commercial manufacturers – among a great many other people – also always labored to fashion an understanding of what modern humankind was like, and how sense and sensation ought to work in a modern society.

Perhaps needless to say, color research did not stop with Munsell chips, though it increasingly became the purview of groups of scientists working within

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<sup>1</sup> Janos Schanda and John Hutchings, “Light and Color, Some Ethical Issues,” *Color Research and Application*, 32: 3, June 2007, pp. 233 -235, on pg. 234.

well-defined organizations rather than the loose (if collaboratively rich) networks that characterized the color work of the late nineteenth and early twentieth centuries.<sup>2</sup> Founded during World War I by American textile manufacturers cut off from their German sources of synthetic dyes, the Color Association of the United States invented the business of color forecasting for textile manufacturers, issuing yearly cards displaying desirable colors in order that the “confusion that has existed in trying to match well-known shades may be done away with.” *The New York Times* estimated that the colors represented in the color cards would “represent 75 per cent. of the color consumption” (presumably of the country).<sup>3</sup> In 1916 scientists working for Eastman Kodak founded the Optical Society of America, which similarly served as a centralizing organ for the many interdisciplinary studies of light being produced by American researchers on topics such as radiometry, photometry, optical instrumentation, and, of course, color. In 1919, the OSA’s American Committee on Colorimetry attempted – albeit with limited success – to come to a consensus definition of color that its member physicists, physiologists and psychologists could all agree on. “Color,” wrote the committee’s chairman Leonard Troland,

is the general name for all sensations arising from the activity of the retina of the eye and its attached nervous mechanisms, this activity being, in nearly every case in the normal individual, a specific response to radiant energy of

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<sup>2</sup> Sean Johnston, *A History of Light and Colour Measurement: Science in the Shadows*, Bristol, UK: Institute of Physics Publishing, 2001.

<sup>3</sup> “Standard Color Card: Has 106 Shades for Use by Textile and Allied Trades,” *New York Times*, 7 Jun. 1915. See also Margaret Hayden Rorke, “The Work of the Textile Color Card Association,” *Journal of the Optical Society of America*, 21:10, 1931, pp. 651-653.



certain wave-lengths and intensities. It may be exemplified by an enumeration of characteristic instances, such as red, yellow, blue, black, white, gray, pink, etc.

As awkwardly as it addressed the physical, physiological, psychophysical, and nomenclatural, issues that had dogged color research over the past three quarters of a century, Troland nevertheless added a footnote explaining that, “[a]lthough color is not a physical entity, it obviously exists outside of us on the surfaces of objects as we see them, such visual objects or perceptions being themselves nothing but arrangements of color areas in space. This statement, however, should not be misinterpreted to mean that the colors are physical or are located on physical objects. There is no reason for supposing that visual objects are identical or coincident with the objects of physical science.” An example of Kuhnian incommensurability *par excellence*, Troland’s disclaimer can be seen both as a disciplinary signpost delineating the physical and psychological views of color, as well as a sign of continuing misgivings among scientists about the nature of color sensations.<sup>4</sup> As a way of dealing with these and other continuing problems with color, in 1931 Munsell’s protégé, Royal Farnum, among other, like-minded color researchers, founded the Inter Society Color Council – a group which included members of the OSA, and the Color Association of the United States – “for the purpose of coordinating the activities of leading technical societies relating to the description, specification, and standardization of color and promoting the practical

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<sup>4</sup> L.T. Troland, “Report of Committee on Colorimetry for 1920-1921,” *Journal of the Optical Society of America*, 533, n3. On paradigm shifts, see Thomas S. Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1996).

application of this knowledge in science, art, and industry.” These and other similar organizations continued to wrestle with and negotiate color perception throughout the twentieth century.

Indeed, among the many tasks pursued by these organizations was the refinement of color standards and models of perceptual color space. Among the foremost of these was the *Commission internationale de l'éclairage* (CIE), a group of American, British, French, German and Japanese color scientists – among whom numbered members of the OSA – charged with establishing international standards pertaining to light and color. In 1931, the CIE sponsored a congress to produce a purely mathematical model of human color perception that could be used for “accurate matching of colors viewed under different lighting conditions, or produced by different sets of ‘primary’ colors.”<sup>5</sup> Rather than employing hue, value and chroma coordinates as had Munsell, the Commission relied on ostensibly more malleable “tristimulus” values – models of the red, green, and blue retinal primary colors that mixed to produce more complicated colors. Expressed as a function of wavelength, tristimulus values could be used to model color space as a cube, and tended to be more versatile than Munsell’s color system, not least of all because they relied on essentially arbitrary definitions of red, green, and blue hues.<sup>6</sup> This said, the CIE’s 1931 trichromatic space could be erratic in certain applications – it appeared, for instance, to overemphasize the color green (figure 6.1). To accommodate the perceptual irregularities of the CIE system, in 1948, Richard S.

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<sup>5</sup> Sean Johnston, “The Construction of Colorimetry by Committee,” *Science in Context*, 9:4, 1996, pp. 387-420, on pg. 399.

<sup>6</sup> Roy Hall, *Illumination and Color in Computer Generated Imagery* (New York: Springer Verlag, 1989) on pg. 46.

Hunter proposed an opponency system based on a reflectance (Lightness) coordinate, plus two opponent pairs: **a**) a red/green coordinate, and **b**) a yellow/blue coordinate. Known as  $L^*a^*b$  color, the system was originally tested on porcelain samples of standardized colors for bathroom fixtures, but is today more commonly used in digital image editing applications.<sup>7</sup> Still other systems provide color matching and definition for applications both general and specific. The HSV (hue, value, saturation) “hexcone” proposed in by Alvy Ray Smith in 1978 for “digital control of television monitors” placed the vertices of the RGB color cube at the corners of a hexagon, with white and black (brightness and darkness) modeled vertically; its kindred system, the HSL model, placed two cones end to end (figure 6.2).<sup>8</sup> The Swedish 1976 Natural Color System, for instance, is an opponency system similar to Hunter’s, used as a general-purpose color scale. And the X-Rite corporation’s 1998 TruShade system provides color analysis specifically for dentistry (figure 6.3). Other systems abound.

The attention paid to color in the decades surrounding the turn of the century continues to have a profound impact on twenty first century American life. The CIE trichromaticity convention, for instance, is a critical part of color definition for computer screens, digital rendering, and desktop publishing, with tristimulus values converted to numerical representations of the red, blue, and green phosphenes used in luminous displays (typically either as percentages of each color,

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<sup>7</sup> see, e.g. Daniel Margulis, *Photoshop Lab Color: The Canyon Conundrum and Other Adventures in the Most Powerful Colorspace* (Berkeley: Pearson Education, 2006).

<sup>8</sup> See Alvy Ray Smith, “Color Gamut Transformation Pairs,” *ACM Computer Graphics (SIGGRAPH 78)*, 12:3, 1978, pp. 12-19, also Hall, *Illumination and Color*, on pg. 46.

or as numbers between 0 and 255).<sup>9</sup> The Munsell system, as discussed in chapter 4, is still in use not only in science, but also in industrial, agricultural and print production. Indeed, the total U.S. market for pigments alone – including household paints, automobile coatings, printing inks, and specialized systems such as Pantone’s color-matching system and the Day-Glo company’s fluorescent colors – make up a 3.4 billion dollar industry, a figure which does not include the substantial money poured into color forecasting, design and analysis, and marketing research.<sup>10</sup> Moreover, beginning with Owens-Corning’s ultimately successful 1985 attempt to trademark the color pink, courts in the United States have increasingly protected specific colors as integral components in corporate trademarks.<sup>11</sup> While on the one hand, some scholars note that there is something “troubling” about “the idea that one can own something so natural and so sensory” as a color, such decisions also prompt us to look, as legal scholar Charlene Elliot puts it at “larger issues of color communication and commerce, ownership and enforcement, representation and signification” in modern American society.<sup>12</sup> The “new era in the representation of

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<sup>9</sup> See, e.g. Hall, *Illumination and Color*, on pg. 56.

<sup>10</sup> Esther D’Amico, “Intensifying Demand for Color Sparks M&A,” *Chemical Week*, 7 Sept. 2005, pg 23. The 3.4 billion figure is up quite a bit from an analysis in *Chemical Week* magazine the previous year, in which Kerri Walsh reported that “The U.S. pigment market for paints and coatings is about \$ 2.4 billion, and growing at 2%/year” – yielding a 2011 figure of approximately \$2.8 billion – well below the figure forecasted the following year. The point – that color is big business – remains the same. (Kerri Walsh, “Pigment Prices Brighten on Higher Demand,” *Chemical Week*, 20 Oct. 2004, on pg. 31).

<sup>11</sup> In re Owens-Corning Fiberglas Corporation, no. 84-1416 , United States Court of Appeals for the Federal Circuit, 774 f.2d 1116; 1985; see also *Qualitex Co. v. Jacobson Prods. Co.*, No. 93-1577, Supreme Court of the United States, 514 U.S. 159; 115 S. Ct. 1300; 131 L. Ed. 2d 248; 1995. Interestingly, in claiming that Qualitex could not include the color green as a part of their patent, Jacobson’s lawyers argued that patenting colors would impinge on a “limited supply of colors that will soon be depleted by competitors” – an argument that the court rejected on the grounds that such an exigency could be revisited in future rulings.

<sup>12</sup> Charlene Elliott, “Purple Past: Color Codification in the Ancient World,” *Law & Social Inquiry*, 33: 1, Winter 2008, pp. 173–194, on pg. 174.

visual information” that historian William Leach saw inaugurated between 1890 and 1910 – due, in no small part, to “new kinds of light and color” as well as new systems for regulating them – continued well into the twentieth and twenty first centuries.<sup>13</sup>

Thus, while scholars such as Sean Johnston see the big debates of color science as largely closed following the CIE meeting of 1931 (and its subsequent refinements to standardized color spaces) editorials like that of Hutchings suggest that Americans are far from finished with talking about color – and, indeed, that color continues to occupy a central, if perhaps more subtle, place in notions of the ways in which perception relates to social order. Jonathan Crary, for instance, introduces his study on epistemes of vision in the eighteenth and nineteenth century with the note that the “formalization and diffusion of computer-generated imagery” represents a “transformation in the nature of visuality probably more profound than the break that separates medieval imagery from Renaissance perspective.” He goes on to note that “emergent technologies of image production are becoming the dominant modes of visualization according to which primary social processes and institutions function” and, indeed, that “they are intertwined with the needs of global information industries and with the expanding requirements of medical, military and police hierarchies.”<sup>14</sup> Reflecting the ways in which Crary’s concerns play out in everyday life, film critic Anthony Lane, reviewing the visually cacophonous, digitally enhanced 2005 movie *Speed Racer*, derided the “achingly blue skies, customized deserts, fantastical mountains, and everything [...]

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<sup>13</sup> Leach, *Land of Desire*, on pg. 50. See especially pp. 39-70.

<sup>14</sup> Crary, *Techniques of the Observer*, on pp. 1-2.

daubed in lollipop hues” as amounting to nothing more or less than “Pop fascism.”<sup>15</sup> In the “rainbow of velocity” conjured by digital imaging technologies – colors rendered into numbers based on CIE coordinates – Lane saw a spectacle designed to at once gratify and subdue the sensations of its audiences. Yes, Lane wrote, the movie was for children, and “a four-year-old will be reduced to a gibbering but highly gratified wreck,” and “[t]rue, our [adult] eyeballs will slowly, but never completely recover, but what” Lane wondered, “of our souls?”

Lane framed his criticism as a joke, but what, indeed, of our souls?

Associations between color, affect, physiology, and political power are not solely the purview of film critics and art historians. In a series of tests, for instance, designed to ascertain the impact of color on task performance, psychologist Andrew Elliot reported that subjects faced with the task of solving anagrams in his laboratory exhibited significantly lower performance when exposed to the color red (e.g. on the covers of their test books) than those who were faced with “neutral” colors such as white or gray, or colors such as green – a result he attributed to both learned color associations, and “a cognitive reinforcing or shaping of biologically based response tendencies.”<sup>16</sup> He also found that red clothing – a red tie, for instance, on men – significantly increased subjects’ appeal to women; though the attraction to red,

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<sup>15</sup> Anthony Lane, “Around the Bend,” *The New Yorker*, 12 May 2008. Lane’s sentiment is not, of course, a new one – Theodoro Adorno and Max Horkheimer explore a similar socio-aesthetic concern with the possibility of mass culture after fascism in *The Dialectic of Enlightenment* (Stanford, CA: Stanford University Press, 2002); Lane, however, explicitly ties his concern in with child development, which has much more rich resonance with the neuroscience of cognition, which, of course, is underwritten by no small amount of research on color vision.

<sup>16</sup> A.J. Elliot, M.A. Maier, A.C. Moller, R. Friedman, J. Meinhardt, “Color and Psychological Functioning: The Effect of Red on Performance in Achievement Contexts,” *Journal of Experimental Psychology: General*, 136, 2007, pp. 154-168.

Elliot clarifies, exists strictly between members of the opposite sex.<sup>17</sup> One can only speculate on what Havelock Ellis, whose 1915 text *Sexual Inversion* documented the fashion for red neckties among sexual “inverts” – and particularly homosexual prostitutes – in New York and Philadelphia would have thought of Elliot’s conclusions.<sup>18</sup>

It is precisely these sorts of associations described by Elliot – and the limits they place on the possibilities of cognitive and perceptual [abilities] – against which historical studies of perception serve as a contrapuntal example. In leapfrogging from the prehistorical past to the here and now, the concept of perceptual reality presented by Elliot – as well, in different forms, by Berlin and Kay, and others who see in Modern conventions of sensation a universal norm of the ways in which people everywhere, at every time, understood themselves and their environment – overlooks the immense work and uncertainty involved in crafting the real; in color as well as in other ways of apprehending the world. This is not to say, of course, that contemporary conceptions of color are wrong, unimportant, or *unreal* – precisely the opposite. It is the attention paid to color, particularly over the past one hundred and fifty years, that has made it so real to modern observers. We *do* talk a lot about color here. And it is the continuing and multivalent dialogue about color – and perception in general – that *produces*, rather than simply reveals, the perceptual experience of modern Americans.

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<sup>17</sup> Andrew J. Elliot, Daniela Niesta Kayser, Tobias Greitemeyer, Stephanie Lichtenfeld, Richard H. Gramzow, Markus A. Maier, Huijun Liu, "Red, Rank, and Romance in Women Viewing Men," *Journal of Experimental Psychology: General*, 139:3 2010, 399–417.

<sup>18</sup> See Havelock Ellis, *Sexual Inversion* (Philadelphia: F. A. Davis 1915) on pp. 350–351.





## **Bibliography**

### **Archives and Manuscript Sources**

Rare Books and Manuscript Library, Columbia University, New York City, New York.  
Ogden N. Rood papers, 1855-1902.  
Christine Ladd-Franklin and Fabian Franklin Papers, 1900-1939

Archives and Special Collections, Massachusetts College of Art and Design,  
Boston, Massachusetts.  
Albert Henry Munsell Papers, 1900 – 1983

Harvard Art Museum Archives, Harvard University, Cambridge, MA.  
Denman Ross papers, 1853-1935

Houghton Library, Harvard University, Cambridge, MA.  
John Jeffries papers, 1768-1819  
Charles Sanders Peirce papers, 1787-1951.

Manuscripts Collection, Princeton University Library, Princeton, NJ  
Ogden N. Rood Correspondence, 1843-1902

Annenberg Rare Book & Manuscript Library, University of Pennsylvania,  
Philadelphia, PA  
Theodore Dreiser Papers

Special Collections Research Center, University of Chicago, Chicago, Ill.  
Benjamin Joy Jeffries, Correspondence, 1877-1891

### **Primary Sources**

"Afraid to Back the Charges." *New York Times*, February 9, 1887.

"Agreeing to the Color Test." *New York Times*, May 5, 1885.

Allen, Grant. *The colour-sense : its origin and development. An essay in comparative psychology*. The English and foreign philosophical library. London: Trübner & Co. 1879.

*Annual report of the Secretary of War*. U.S. Govt. Print. Off. 1915.

"Army and Navy News." *New York Times*, June 10, 1887.

- Baldwin, James Mark. *Dictionary of philosophy and psychology; including many of the principal conceptions of ethics, logic, aesthetics, philosophy of religion, mental pathology, anthropology, biology, neurology, physiology, economics, political and social philosophy, philology, physical science, and education; and giving a terminology in English, French, German and Italian.* New York: The Macmillan Co., 1901.
- Beer, Thomas. *The mauve decade : American life at the end of the nineteenth century.* New York: Carroll & Graf Publishers, 1997.
- Bezold, Wilhelm. *The theory of color in its relation to art and art-industry.* Trans. S. Koehler. Boston: L. Prang and Co., 1876.
- Blake, L. I. and W. S. Franklin. "Color-Blindness a Product of Civilization." *Science* 13, no. 317 (March 1, 1889): 170-171.
- . "In Regard to Color-Blindness among Indians." *Science* 21, no. 539 (June 2, 1893): 297-298.
- Bolles, Charles. *Dictionary of correspondences, representatives, and significatives, derived from the word of the Lord; extracted from the writing of Emanuel Swedenborg.* 4th ed. Boston: Clapp, 1863.
- Bradley, Milton. *Color in the school-room : a manual for teachers.* Springfield, MA.: M. Bradley Co. 1890.
- . *Elementary color.* Springfield, MA.: Milton Bradley Co. 1895.
- . *Water colors in the schoolroom.* Springfield, MA.: M. Bradley Co. 1900.
- . *Water colors in the schoolroom.* Springfield, MA.: M. Bradley Co. 1915.
- . "The Color Question Again." *Science* 19, no. 477 (March 25, 1892): 175-176.
- Brewster, David. *A treatise on optics.* London: Longman, Brown, Green & Longman's, 1852.
- Church, A. H. *The chemistry of paints and painting.* 3rd ed. London: Seeley and Co. Ltd. 1901.
- "Color Blindness." *New York Times*, February 12, 1893.
- "Color Blindness in Connecticut." *New York Times*, March 13, 1881.
- "Color Blindness of Railroad Men." *New York Times*, May 23, 1879.

- "Color Blindness." *New York Times*, September 3, 1879.
- "Color Blindness." *New York Times*, June 1, 1881.
- "Color Blindness." *New York Times*, October 26, 1883.
- "Color Blindness." *New York Times*, May 6, 1888.
- "Color Test Examinations." *New York Times*, April 26, 1885.
- "Color-Blind Examinations." *New York Times*, May 1, 1885.
- "Color-Blind Railroad Men." *New York Times*, August 17, 1879.
- "Color-Blindness." *New York Times*, August 25, 1878.
- "Color-Blindness." *New York Times*, January 26, 1879.
- "Color-Blindness." *New York Times*, September 8, 1879.
- "Color-Blindness and its Dangers." *New York Times*, July 8, 1878.
- "Color-blindness." *Los Angeles Times*, September 4, 1893.
- "Color-Blindness." *New York Times*, March 25, 1877.
- "Color Blindness." *New York Times*, March 24, 1878.
- "Color-Blindness." *New York Times*, November 30, 1879.
- Cross, Anson K. *Color study, a manual for teachers and students*. Boston: Ginn & Co., 1895.
- "Danger from Color Blindness." *New York Times*, June 10, 1881.
- "Dangers in the Tunnel." *New York Times*, February 25, 1891.
- "Discharged for Color-Blindness." *New York Times*, August 2, 1885.
- "Dissatisfied Railroad Employes." *New York Times*, April 30, 1885.
- Dimmick, Forrest L. and Cyril H. Holt. "Gray and the Color Pyramid." *The American Journal of Psychology* 41, no. 2 (April 1, 1929): 284-290.
- Dove, Heinrich Wilhelm. *Darstellung der Farbenlehre und optische Studien*. Berlin: G. W. F. Müller, 1853.

- Du Bois, W. E. B. *The quest of the silver fleece : a novel*. New York: Harlem Moon, 2004.
- "The Effect of Colors on the Mind." *New York Times*, December 4, 1887.
- Ellis, Havelock. *Man and Woman; a Study of Secondary Sexual Characters*. 6th ed. London: A. & C. Black, 1926.
- Ellis, Havelock and John Addington Symonds. *Sexual inversion : a critical edition*. Houndmills, Basingstoke, Hampshire: Palgrave Macmillan, 2008.
- "English Tests of Color Blindness." *New York Times*, November 10, 1892.
- Fee, John. "Color-Blindness, and Railway Accidents." *Transactions of the Kansas Academy of Science (1872-1880)* 7 (January 1, 1879): 29-37.
- "Form Blindness." *New York Times*, January 22, 1885.
- "Founding a New Science." *New York Times*, January 18, 1898.
- Garth, Thomas R. and Electa Penina Porter. "The Color Preferences of 1032 Young Children." *The American Journal of Psychology* 46, no. 3 (July 1, 1934): 448-451.
- Garth, Thomas R. Mathilde R. Moses, and Corrine N. Anthony. "The Color Preferences of East Indians." *The American Journal of Psychology* 51, no. 4 (October 1, 1938): 709-713.
- Gates, Elmer. *The relations and development of the mind and brain*. New York: Theosophical Pub. Co. 1904.
- Gatschet, Albert S. "Adjectives of Color in Indian Languages." *The American Naturalist* 13, no. 8 (1879): 475-485.
- Gesell, Arnold, and Beatrice Chandler Gesell. *The normal child and primary education*. New York: Ginn, 1912.
- Gibson, Richard. *The art of dyeing all colors on raw cotton or cotton waste, for the purpose of working with raw wool: also, the methods of dyeing all colors in the piece, in two sections ; The system and science of colors, or the principles and practise of woollen dyeing ; The properties and composition of the dyestuff and chymical compounds which enter into the constitution of colors*. London: J. Rollinson, 1861.

- Gould, Benjamin Apthorp. *Investigations in the military and anthropological statistics of american soldiers*. New York: Published for the U.S. Sanitary Commission by Hurd and Houghton, 1869.
- "Green and Red Lights." *New York Times*, December 17, 1889.
- Guilford, J. P. and Patricia C. Smith. "A System of Color-Preferences." *The American Journal of Psychology* 72, no. 4 (December 1, 1959): 487-502.
- Gundlach, Carol, and Constance Macoubrey. "The Effect of Color on Apparent Size." *The American Journal of Psychology* 43, no. 1 (January 1, 1931): 109-111.
- Haddon, Alfred C. *Reports of the Cambridge Anthropological Expedition to Torres Straits*, Cambridge: The University press, 1901.
- Hall, Granville Stanley. *Educational problems*. New York: D. Appleton and Co., 1911.
- Hall, Roy. *Illumination and Color in Computer Generated Imagery*. New York: Springer-Verlag, 1989.
- Hallock, W. and R. Gordon. "Color Standards." *Science* 6, no. 136. (1897): 214-215.
- Haney, James Parton. *Art education in the public schools of the United States: a symposium prepared under the auspices of the American committee of the third International congress for the development of drawing and art teaching, London, August, 1908*. New York: American Art Annual, 1908.
- Harlow, W. B. "Color-Blindness." *Science* 11, no. 261 (February 3, 1888): 57-58.
- "Heedless of any Danger." *New York Times*, December 29, 1891.
- Heider, Eleanor Rosch. "Probabilities, Sampling, and Ethnographic Method: The Case of Dani Colour Names." *Man* 7, no. 3. (1972): 448-466.
- Henmon, Vivian A. C. "The Detection of Color-Blindness." *The Journal of Philosophy, Psychology and Scientific Methods* 3, no. 13 (June 21, 1906): 341-344.
- "Her Point of View." *New York Times*, October 11, 1891.
- Hodge, Charles. *Systematic Theology*, New York: Scribner, Armstrong, and Co., 1873.
- Iijima, Toshiro, Wolfgang Wenning, and Heinrich Zollinger. "Cultural Factors of Color Naming in Japanese: Naming Tests with Japanese Children in Japan and Europe." *Anthropological Linguistics* 24, no. 2 (July 1, 1982): 245-262.

- . “Cultural Factors of Color Naming in Japanese: Naming Tests with Japanese Children in Japan and Europe.” *Anthropological Linguistics* 24, no. 2 (July 1, 1982): 245-262.
- “An Instructor with a Theory.” *New York Times*, August 28, 1885.
- Jameson, Robert. *A treatise on the external, chemical and physical characters of minerals*, 1816.
- Jeffries, B. Joy. *Color-blindness : its dangers and its detection*. Boston: Houghton, Osgood and Company, 1880.
- . *The eye in health and disease: being a series of articles on the anatomy and physiology of the human eye, and its surgical and medical treatment*. Boston: Lee and Shepard. 1871.
- . “How The Color-Blind See Colors.” *New York Times*, November 5, 1883.
- Jennings, John Ellis. *Color-vision and color-blindness. A practical manual for railroad surgeons*. Philadelphia: F. A. Davis, 1896.
- Katzin, Dorothy, and Elsie Murray. “Instability in Color-Naming in Normal and Anomalous Observers.” *The American Journal of Psychology* 46, no. 4 (October 1, 1934): 611-620.
- Kay, Paul, and Brent Berlin. *Basic color terms; their universality and evolution*. Berkeley: University of California Press, 1969.
- Kay, Paul, and Luisa Maffi. “Color Appearance and the Emergence and Evolution of Basic Color Lexicons.” *American Anthropologist* 101, no. 4. (December 1, 1999): 743-760.
- Khosroshahi, Fatemeh. “Penguins Don’t Care, but Women Do: A Social Identity Analysis of a Whorfian Problem.” *Language in Society* 18, no. 4 (December 1, 1989): 505-525.
- Kirkman, Marshall Monroe. *Railway train and station service: Describing the organization and manner of operating trains, and the duties of train and station officials*. Chicago: C.N. Trivess, 1884.
- Ladd-Franklin, Christine. *Colour and colour theories*. London: K. Paul, Trench, Trubner & co. ltd., 1929.

- Landa, Edward R. and Mark D. Fairchild. "Charting Color from the Eye of the Beholder: A century ago, artist Albert Henry Munsell quantified colors based on how they appear to people; specializations of his system are still in wide scientific use." *American Scientist* 93, no. 5 (2005): 436-443.
- Lanman, Susan W. "Colour in the Garden: 'Malignant Magenta'." *Garden History* 28, no. 2 (December 1, 2000): 209-221.
- Larsson, Carl. *Carl Larsson: The Autobiography of Sweden's Most Beloved Artist*. Penfield Press, 1992.
- Lee, S., Heinrich H Bülthoff, Tomaso Poggio, and IEEE/CS International Workshop BMCV 2000 2000 : Seoul, Korea). *Biologically motivated computer vision : First IEEE International Workshop, BMCV 2000, Seoul, Korea, May 15-17, 2000 : proceedings*. Berlin: Springer, 2000.
- Lenneberg, Eric H. *Biological foundations of language*. New York: Wiley, 1967.
- Lewis, Charlton. *Place of mathematics in university education. Inaugural address of Charlton T. Lewis, professor of pure mathematics in Troy university, delivered before the trustees at their annual meeting July 20th*. Troy N.Y.: A.W. Scribner and Co., 1859.
- "Lieut. Meig's Defect." *New York Times*, June 24, 1891.
- Lippmann, Walter. *Drift and mastery : an attempt to diagnose the current unrest*. New York: M. Kennerley, 1914.
- Lo, Ch'u'an-Fang. "The Affective Values of Color Combinations." *The American Journal of Psychology* 48, no. 4 (October 1, 1936): 617-624.
- "The Locomotive Engineers." *New York Times*, October 20, 1881.
- Lonsdale, Henry. *The worthies of Cumberland. John Dalton*. London, 1874.
- Lovecraft, H.P. *H.P. Lovecraft: The Fiction - Complete and Unabridged*. Barnes and Noble, 2008.
- Lucy, John A. and Richard A. Shweder. "Whorf and His Critics: Linguistic and Nonlinguistic Influences on Color Memory." *American Anthropologist* 81, no.3. (1979): 581-615.
- "Managing the Railways." *New York Times*, April 29, 1885.
- Marmor, Judd. *Sexual inversion; the multiple roots of homosexuality*. New York: Basic Books, 1965.

- McClintock, John, and James Strong. *Cyclopedia of Biblical, theological, and ecclesiastical literature: Supplement*. Harper, 1885.
- McClure, M. F. "A 'Color Illusion'." *The American Journal of Psychology* 12, no. 2 (January 1, 1901): 178-184.
- Michaels, George M. "Color Preference According to Age." *The American Journal of Psychology* 35, no. 1 (January 1, 1924): 79-87.
- Miller, Gerrit S. "Descriptions of Six New American Rabbits." *Proceedings of the Academy of Natural Sciences of Philadelphia* 51, no. 2 (April 1, 1899): 380-390.
- . "Twenty New American Bats." *Proceedings of the Academy of Natural Sciences of Philadelphia* 54, no. 2 (May 1, 1902): 389-412.
- Millikan, Robert Andrews. *Autobiography*. New York: Prentice-Hall, 1950.
- Milton Bradley Company. *1905 catalogue of Bradley's kindergarten material and school aids*. Springfield, MA.: Milton Bradley Co. 1905.
- . *Catalogue of Bradley's kindergarten material and school supplies, 1907 (48th year)*. Springfield, MA.: Milton Bradley Co. 1907.
- Mumford, Lewis. *The brown decades : a study of the arts in America, 1865-1895*. Rev. New York: Dover, 1971.
- Murphy, Joseph John. *Habit and intelligence in their connexion with the laws of matter and force: a series of scientific essays*. New York: Macmillan and Co., 1869.
- Murray, Elsie. "Alleged Cures of Color Blindness." *The American Journal of Psychology* 58, no. 2 (April 1, 1945): 253-261.
- . "Anomalies in Color Vision." *The Scientific Monthly* 57, no. 4 (October 1, 1943): 322-331.
- . "Binocular Fusion and the Locus of 'Yellow'." *The American Journal of Psychology* 52, no. 1 (January 1, 1939): 117-121.
- . "Color Blindness and Borderline Cases." *Science* 96, no. 2484. (1942): 133-135.
- . "Mass-Testing of Color Vision; A Simplified and Accelerated Technique." *The American Journal of Psychology* 61, no. 3 (July 1, 1948): 370-385.



- . "Some Uses and Misuses of the Term 'Aesthetic.'" *The American Journal of Psychology* 42, no. 4 (October 1, 1930): 640-644.
- . "The Ishihara Test for Color-Blindness: A Point in Ethics." *The American Journal of Psychology* 47, no. 3 (July 1, 1935): 511-513.
- . "The Use of Munsell Papers in Tests Diagnostic of Color Weakness, Color Blindness, and Vocational Color Capacity." *The American Journal of Psychology* 53, no. 3 (July 1, 1940): 445-449.
- "The National Bureau of Standards." *Science* 13, no. 325. (March 22, 1901): 474-475.
- "National Capital Topics." *New York Times*, January 24, 1882.
- The National Cyclopaedia of American Biography*. New York: J.T. White, 1904.
- "New Notions of Color." *New York Times*, March 3, 1878.
- "Object to Being Examined for Color-Blindness." *Los Angeles Times*, April 29, 1885.
- Parker, G. H. "Integumentary Color Changes of Elasmobranch Fishes Especially of *Mustelus*." *Proceedings of the American Philosophical Society* 77, no. 3 (March 31, 1937): 223-247.
- Payne, George. *Elements of mental and moral science, designed to exhibit the original susceptibilities of the mind, and the rule by which the rectitude of any of its states or feelings should be judged*. London: Printed for B.J. Holdsworth, 1828.
- Pillsbury, J. H. "A New Color Scheme." *Science* 19, no. 473 (February 26, 1892): 114.
- . "A New Color Scheme." *Science* 19, no. 473 (February 26, 1892): 114.
- . "On the Color Description of Flowers." *Botanical Gazette* 19, no. 1 (January 1, 1894): 15-18.
- . "Spectrum Color Standards." *Science* 6, no. 133. (July 16, 1897): 89-91.
- . "Spectrum Color Standards." *Science* 6, no. 133. (July 16, 1897): 89-91.
- . "The Standard Color Scheme." *Science* 21, no. 540 (June 9, 1893): 310-311.
- "Primitive Races of Mankind and the Average American." *New York Times*, May 7, 1905.

- "Prof. Nordenskjold's Discoveries." *New York Times*, August 30, 1879.
- "Railroad Men and Matters." *New York Times*, May 15, 1894.
- "Railroads of the State." *New York Times*, January 15, 1884.
- "Railway Management." *New York Times*, January 12, 1890.
- Ratliff, Floyd. "On the Psychophysiological Bases of Universal Color Terms." *Proceedings of the American Philosophical Society* 120, no. 5 (October 15, 1976): 311-330.
- "Reading Employes Firm." *New York Times*, August 8, 1887.
- "A Report on the Present Functions and Operations of the National Bureau of Standards." *Science* 119, no. 3085. (February 12, 1954): 195-200.
- "Reviewing the Meigs Case." *New York Times*, July 12, 1891.
- Reynolds, Edward. *Hints to students on the use of the eyes*. Edinburgh: Clark, 1835.
- Ridgway, Robert. *A nomenclature of colors for naturalists : and compendium of useful knowledge for ornithologists ; with ten colored plates and seven plates of outline illustrations*. Boston: Little, Brown, and Co., 1886.
- . *Color standards and color nomenclature*. Washington, D.C.: The author, 1912.
- . "Ridgway's Nomenclature of Colors and Compendium." *Science* 9, no. 213 (March 4, 1887): 222.
- Roberts, John M, and Eric H Lenneberg. *The language of experience; a study in methodology*. Baltimore: Waverly Press, 1956.
- Rood, Ogden N. *Modern chromatics, with applications to art and industry*. New York: D. Appleton and Company, 1879.
- . *The practical value of physical science. Inaugural address*. Troy N.Y.: W.H. Young, 1859.
- "Sanitary Supervision." *New York Times*, May 24, 1878.
- Schwartz, Steven H. *Visual perception: a clinical orientation*. Norwalk, Conn.: Appleton & Lange, 1994.
- Scripture, E. W. *Thinking, feeling, doing*. Meadville [Pa.]: Flood and Vincent, 1895.

- "A Season of Strikes." *Los Angeles Times*, August 16, 1892.
- "Sense of Color." *New York Times*, May 4, 1879.
- "Shakespeare's Color Names." *New York Times*, March 2, 1879.
- Shevell, Steven K. *The science of color*. 2nd ed. Amsterdam: Elsevier, 2003.
- Soja, Nancy N. "Young Children's Concept of Color and Its Relation to the Acquisition of Color Words." *Child Development* 65, no. 3 (June 1, 1994): 918-937.
- "State Railroad Control." *New York Times*, January 15, 1884.
- Stiles, W. S, and Günter Wyszecki. *Color science : concepts and methods, quantitative data and formulae*. 2nd ed. The Wiley series in pure and applied optics. New York: Wiley, 1982.
- Strong, George Templeton. *The diary of George Templeton Strong*. New York: Octagon Books, 1974.
- "Suspended Because Color Blind." *New York Times*, March 3, 1884.
- Syme, Patrick, and Abraham Gottlob Werner. *Werner's nomenclature of colours, with additions by P. Syme*, 1814.
- Tanner, Amy Eliza. *The child : his thinking, feeling, and doing*. Chicago: Rand, McNally & Company, 1904.
- "Testing Color Blindness." *New York Times*, October 25, 1883.
- "Testing Sight and Hearing." *New York Times*, August 6, 1887.
- "The Theory of Daltonism." *New York Times*, June 13, 1880.
- Titchener, E. B. "On Ethnological Tests of Sensation and Perception with Special Reference to Tests of Color Vision and Tactile Discrimination Described in the Reports of the Cambridge Anthropological Expedition to Torres Straits." *Proceedings of the American Philosophical Society* 55, no. 3 (January 1, 1916): 204-236.
- "Tobacco." *New York Times*, August 21, 1892.
- "Tobacco and Color Blindness." *New York Times*, October 3, 1886.
- "Tobacco Blindness." *Los Angeles Times*, March 13, 1887.

"Too Near-Sighted for Work." *New York Times*, January 18, 1889.

"To Restrict Immigration." *New York Times*, February 11, 1902.

"Tricks of the Color Blind." *New York Times*, July 17, 1892.

"The Use of the Eyesight." *New York Times*, May 3, 1880.

von Wattenwyl, André, and Heinrich Zollinger. "Color-Term Salience and Neurophysiology of Color Vision." *American Anthropologist* 81, no. 2. (June 1, 1979): 279-288.

———. "The Color Lexica of Two American Indian Languages, Quechi and Misquito: A Critical Contribution to the Application of the Whorf Thesis to Color Naming." *International Journal of American Linguistics* 44, no. 1 (January 1, 1978): 56-68.

von Wattenwyl, Andreas, and Heinrich Zollinger. "Color-Term Salience and Neurophysiology of Color Vision." *American Anthropologist* 81, no. 2. (June 1, 1979): 279-288.

Werner, John Simon, and Leo M Chalupa. *The visual neurosciences*. Cambridge, MA.: MIT Press, 2004.

Whorf, Benjamin Lee. *Language, thought, and reality : selected writings of Benjamin Lee Whorf*. Cambridge, MA.: Technology Press of Massachusetts Institute of Technology, 1956.

Wierzbicka, Anna. "There Are No 'Color Universals' but There Are Universals of Visual Semantics." *Anthropological Linguistics* 47, no. 2 (July 1, 2005): 217-244.

Woodworth, R. S. "Racial Differences in Mental Traits." *Science* 31, no. 788. (February 4, 1910): 171-186.

Zakia, Richard D, and Richard D Zakia. *Perception and imaging*. Boston: Focal Press, 1997.

## **Secondary Sources**

Abir-Am, Pnina G, and Dorinda Outram. *Uneasy careers and intimate lives: women in science, 1789-1979*. New Brunswick: Rutgers University Press, 1987.

- Astore, William J. *Observing God : Thomas Dick, evangelicalism, and popular science in Victorian Britain and America*. Burlington, Vt.: Ashgate, 2001.
- Bailkin, Jordanna. "Color Problems: Work, Pathology, and Perception in Modern Britain." *International Labor and Working-Class History*, no. 68 (October 1, 2005): 93-111.
- Ball, Philip. *Bright earth: art and the invention of color*. New York: Farrar, Straus and Giroux, 2002.
- Becker, Bernard Henry. *Scientific London*. London: Cass, 1968.
- Bederman, Gail. *Manliness & civilization : a cultural history of gender and race in the United States, 1880-1917*. Chicago: University of Chicago Press, 1995.
- Belt, Henk Van Den. "Why Monopoly Failed: The Rise and Fall of Société La Fuchsine." *The British Journal for the History of Science* 25, no. 1 (March 1, 1992): 45-63.
- Ben-Chaim, Michael. "The Discovery of Natural Goods: Newton's Vocation as an 'Experimental Philosopher'." *The British Journal for the History of Science* 34, no. 4 (December 1, 2001): 395-416.
- Benthien, Claudia. *Skin: on the cultural border between self and the world*. New York: Columbia University Press, 2002.
- Bently, Lionel, and Leo Flynn. *Law and the senses: sensational jurisprudence*. London: Pluto Press, 1996.
- Birren, Faber. *Color & human response: aspects of light and color bearing on the reactions of living things and the welfare of human beings*. New York: Van Nostrand Reinhold Co. 1978.
- . *Color perception in art*. New York: Van Nostrand Reinhold Co. 1976.
- . *Color; a survey in words and pictures, from ancient mysticism to modern science*. New Hyde Park, N.Y.: University Books, 1963.
- . *The story of color, from ancient mysticism to modern science*. Westport, Conn.: The Crimson Press, 1941.
- Bjelajac, David. *Washington Allston, Secret Societies, and the Alchemy of Anglo-American Painting*. Cambridge: Cambridge University Press, 1997.

- . *Washington Allston, Secret Societies, and the Alchemy of Anglo-American Painting*. Cambridge: Cambridge University Press, 1997.
- Blakeslee, Sandra, and V. S Ramachandran. *Phantoms in the brain : human nature and the architecture of the mind*. London: Fourth Estate, 1998.
- Boring, Edwin G. *A history of experimental psychology*. New York: Appleton-Century-Crofts, 1950.
- . *Sensation and perception in the history of experimental psychology*. New York: Irvington Publishers, 1977.
- Bornstein, Marc H. "The Influence of Visual Perception on Culture." *American Anthropologist* 77, no. 4. (December 1, 1975): 774-798.
- Bozeman, Theodore Dwight. *Protestants in an age of science : the Baconian ideal and ante-bellum American religious thought*. Chapel Hill: University of North Carolina Press, 1977.
- Brownlee, Peter John. "Color Theory and the Perception of Art." *American Art* 23, no. 2 (June 1, 2009): 21-24.
- Bruce, Robert V. *The launching of modern American science, 1846-1876*. Cornell paperbacks. Impact of the Civil War. Ithaca, N.Y.: Cornell University Press, 1988.
- Burgess, George K. "The National Bureau of Standards." *The Scientific Monthly* 36, no. 3 (March 1, 1933): 200-212.
- Burwick, Frederick. *The damnation of Newton*. Walter de Gruyter, 1986.
- Cahan, David. *Hermann von Helmholtz and the foundations of nineteenth-century science*. Berkeley: University of California Press, 1993.
- Cahan, David, and Hermann von Helmholtz. *Science and culture: popular and philosophical essays*. Chicago: University of Chicago Press, 1995.
- Capozzola, Christopher. *Uncle Sam wants you: World War I and the making of the modern American citizen*. Oxford: Oxford University Press, 2008.
- Cary, Richard. *Critical art pedagogy*. Taylor & Francis, 1998.
- Chandler, Alfred D. *The visible hand : the managerial revolution in American business*. Cambridge, MA.: Belknap Press, 1977

- Cronon, William. *Nature's metropolis : Chicago and the Great West*. New York: W. W. Norton, 1991.
- Chomsky, Noam. *Syntactic structures*. Gravenhage: Mouton, 1957.
- Classen, Constance. *The book of touch*. Sensory formations series. Oxford: Berg, 2005.
- . *The color of angels : cosmology, gender and the aesthetic imagination*. London: Routledge, 1998.
- . *Worlds of sense : exploring the senses in history and across cultures*. London: Routledge, 1993.
- Coalter, Milton J, John M Mulder, and Louis Weeks. *The Pluralistic vision : Presbyterians and mainstream Protestant education and leadership*. The Presbyterian presence. Louisville, Ky.: Westminster/John Knox Press, 1992.
- Cohen, Daniel J. *Equations from God : pure mathematics and Victorian faith*. Johns Hopkins studies in the history of mathematics. Baltimore: Johns Hopkins University Press, 2007.
- Cohen, Jonathan D, and Mohan Matthen. *Color ontology and color science*. Life and mind. Cambridge, MA.: MIT Press, 2010.
- Connor, Steven. *The book of skin*. Ithaca, N.Y.: Cornell University Press, 2004.
- Corbin, Alain. *The foul and the fragrant: odor and the French social imagination*. Cambridge, MA.: Harvard University Press, 1986.
- Corti, Walter Robert, *The philosophy of William James*. Hamburg: Meiner, 1976.
- Crary, Jonathan. *Suspensions of perception: attention, spectacle, and modern culture*. Cambridge, MA.: MIT Press, 1999.
- . *Techniques of the observer: on vision and modernity in the nineteenth century*. Cambridge, MA.: MIT Press, 1990.
- . "Unbinding Vision." *October* 68 (April 1, 1994): 21-44.
- Cravens, Hamilton, Alan I Marcus, and David M Katzman. *Technical knowledge in American culture : science, technology, and medicine since the early 1800s*. History of American science and technology series. Tuscaloosa: University of Alabama Press, 1996.

- Croce, Paul Jerome. *Science and religion in the era of William James*. Chapel Hill: University of North Carolina Press, 1995.
- Daniels, George H. *American science in the age of Jackson*. New York: Columbia University Press, 1968.
- . *Nineteenth-century American science; a reappraisal*. Evanston Ill.: Northwestern University Press, 1972.
- Danziger, Kurt. *Constructing the subject*. Cambridge: Cambridge University Press, 1994.
- Davenport, F. Garvin, Spencer F. Baird, and Clarence King. "Robert Ridgway: Illinois Naturalist." *Journal of the Illinois State Historical Society (1908-1984)* 63, no. 3 (October 1, 1970): 271-289.
- Davis, Elisabeth B. "Ridgway's 'Color Standards': A Classic in Biology." *Bios* 56, no. 3 (1985): 143-152.
- Degler, Carl N. *In search of human nature : the decline and revival of Darwinism in American social thought*. New York: Oxford University Press, 1991.
- Delbourgo, James. *A most amazing scene of wonders : electricity and enlightenment in early America*. Cambridge, MA.: Harvard University Press, 2006.
- DeLue, Rachael Ziady. *George Inness and the science of landscape*. Chicago: University of Chicago Press, 2004.
- Deutscher, Guy. *Through the language glass : why the world looks different in other languages*. New York: Metropolitan Books/Henry Holt and Co. 2010.
- Edwards, Elizabeth, Chris Gosden, and Ruth B Phillips. *Sensible objects : colonialism, museums and material culture*. Oxford: Berg, 2006.
- Engel, Stephen A. "Using Neuroimaging to Measure Mental Representations: Finding Color-Opponent Neurons in Visual Cortex." *Current Directions in Psychological Science* 8, no. 1 (February 1, 1999): 23-27.
- Everitt, C. W. F. *James Clerk Maxwell : physicist and natural philosopher*. New York: Scribner, 1975.
- Fairchild, Mark D. *Color appearance models*. 2nd ed. Wiley-IS&T series in imaging science and technology. Chichester, West Sussex, England: J. Wiley, 2005.
- Finger, Stanley. *Origins of neuroscience: a history of explorations into brain function*. New York: Oxford University Press, 1994.



- Foley, William A. *Anthropological linguistics: an introduction*. Malden, MA: Blackwell Publishers, 1997.
- Frank, Marie. "Denman Waldo Ross and the Theory of Pure Design." *American Art* 22, no. 3 (2008): 72-89.
- Freedman, Paul H. *Out of the East: spices and the medieval imagination*. New Haven: Yale University Press, 2008.
- French, Bryant Morey. *Mark Twain and The gilded age, the book that named an era*. Dallas: Southern Methodist University Press, 1965.
- Gage, John. *Color and culture: practice and meaning from antiquity to abstraction*. Boston: Little, Brown, 1993.
- . *Color and meaning: art, science, and symbolism*. Berkeley: University of California Press, 1999.
- Gamst, Frederick C. "Rethinking Leach's Structural Analysis of Color and Instructional Categories in Traffic Control Signals." *American Ethnologist* 2, no. 2 (May 1, 1975): 271-296.
- Garfield, Simon. *Mauve: how one man invented a color that changed the world*. New York: Norton, 2001.
- Gilmore, Glenda Elizabeth, and Richard Hofstadter. *Who were the progressives? Historians at work*. Houndmills, Basingstoke, Hampshire: Palgrave, 2002.
- Gottschalk, H. B. "The de Coloribus and Its Author." *Hermes* 92, no. 1 (1964): 59-85.
- Gourlie, John Hamilton. *The origin and history of "The Century"*. New York: W.C. Bryant & co. printers, 1856.
- Grossman, James R. *Land of hope : Chicago, Black southerners, and the Great Migration*. Chicago: University of Chicago Press, 1989.
- Halbertsma, Klaas Tjalling Agnus. *A History of the Theory of Colour*. Amsterdam: Swets & Zeilinger, 1949.
- Harris, Harry. "Robert Ridgway. With a Bibliography of His Published Writings and Fifty Illustrations." *The Condor* 30, no. 1 (January 1, 1928): 5-118.
- Helmreich, Stefan. *Alien ocean: anthropological voyages in microbial seas*. Berkeley: University of California Press, 2009.

- Hofstadter, Richard. *The age of reform: from Bryan to F. D. R.* New York: Knopf, 1955.
- . *Academic freedom in the age of the college.* New York: Columbia University Press, 1961.
- . *Social Darwinism in American thought.* Boston: Beacon Press, 1992.
- Hollinger, David A. *In the American province: studies in the history and historiography of ideas.* Bloomington: Indiana University Press, 1985.
- . *Science, Jews, and secular culture: studies in mid-twentieth-century American intellectual history.* Princeton, N.J.: Princeton University Press, 1996.
- Homburg, Ernst. "The Emergence of Research Laboratories in the Dyestuffs Industry, 1870-1900." *The British Journal for the History of Science* 25, no. 1 (March 1, 1992): 91-111.
- Hornix, Willem J. "From Process to Plant: Innovation in the Early Artificial Dye Industry." *The British Journal for the History of Science* 25, no. 1 (March 1, 1992): 65-90.
- Hovenkamp, Herbert. *Science and religion in America, 1800-1860.* Philadelphia: University of Pennsylvania Press, 1978.
- Howes, David. *Empire of the senses : the sensual culture reader.* Oxford: Berg, 2005.
- Howes, David, Anthony Synnott, and Constance Classen. *Aroma : the cultural history of smell.* London: Routledge, 1994.
- Hubbell, Alvin A. *The development of ophthalmology in America 1800 to 1870. A contribution to ophthalmologic history and biography. An address delivered in abstract before the section of ophthalmology of the American Medical Association, June 4, 1907.* Chicago: W.T. Keener & Co., 1908.
- Hunt, David M. Kanwaljit S. Dulai, James K. Bowmaker, and John D. Mollon. "The Chemistry of John Dalton's Color Blindness." *Science* 267, no. 5200. (February 17, 1995): 984-988.
- Jackson, Myles W. "A Spectrum of Belief: Goethe's 'Republic' versus Newtonian 'Despotism'." *Social Studies of Science* 24, no. 4 (November 1, 1994): 673-701.
- . "Putting the Subject back into Color: Accessibility in Goethe's Zur Farbenlehre." *Perspectives on Science* 16, no. 4 (December 1, 2008): 378-391.
- Jacobson, Matthew Frye. *Barbarian virtues: the United States encounters foreign peoples at home and abroad, 1876-1917.* New York: Hill and Wang, 2000.

- Jay, Martin. *Downcast eyes: the denigration of vision in twentieth-century French thought*. Berkeley: University of California Press, 1993.
- Johnson, Phillip E. *The wedge of truth: splitting the foundations of naturalism*. Downers Grove, Ill.: InterVarsity Press, 2000.
- Johnston, Sean. *A history of light and colour measurement: science in the shadows*. Bristol: Institute of Physics Publishing, 2001.
- Jones, Caroline A. *Eyesight alone: Clement Greenberg's modernism and the bureaucratization of the senses*. Chicago: University of Chicago Press, 2005.
- Jones, Caroline A, and Bill Arning. *Sensorium : embodied experience, technology, and contemporary art*. Cambridge, MA.: MIT Press, 2006.
- Jones, David Shumway. *Rationalizing epidemics: meanings and uses of American Indian mortality since 1600*. Cambridge, MA.: Harvard University Press, 2004.
- Kanigel, Robert. *The one best way: Frederick Winslow Taylor and the enigma of efficiency*. New York: Viking, 1997.
- Kay, Lily E. *Who wrote the book of life?: a history of the genetic code*. Writing science. Stanford, Calif.: Stanford University Press, 2000.
- Kett, Joseph F. *The formation of the American medical profession: the role of institutions, 1780-1860*. Westport, Conn.: Greenwood Press, 1980.
- Kevles, Daniel J. *The physicists: the history of a scientific community in modern America*. Cambridge, MA.: Harvard University Press, 1987.
- Kohl, Walter Joseph. *The science curriculum in the seminary*. Saint Bonaventure, N. Y.: Saint Bonaventure's College Press, 1934.
- Kohlstedt, Sally Gregory. *The formation of the American scientific community: the American Association for the Advancement of Science, 1848-60*. Urbana: University of Illinois Press, 1976.
- Kohlstedt, Sally Gregory, and Margaret W Rossiter. *Historical writing on American science: perspectives and prospects*. Baltimore, Md.: Johns Hopkins University Press, 1986.
- Korsmeyer, Carolyn. *The taste culture reader: experiencing food and drink*. English. Sensory formations series. Oxford: Berg, 2005.

- Kuehni, Rolf G. *Color space and its divisions: color order from antiquity to the present*. Hoboken, N.J.: Wiley-Interscience, 2003.
- . *Color, essence and logic*. New York: Van Nostrand Reinhold, 1983.
- Kuschel, Rolf, and Torben Monberg. "‘We Don’t Talk Much About Colour Here’: A Study of Colour Semantics on Bellona Island." *Man* 9, no. 2. (June 1, 1974): 213-242.
- Leach, Edmund Ronald. *Lévi-Strauss*. London: Fontana Press, 1996.
- Lassman, Thomas C. "Government Science in Postwar America: Henry A. Wallace, Edward U. Condon, and the Transformation of the National Bureau of Standards, 1945–1951." *Isis* 96, no. 1 (March 1, 2005): 25-51.
- Leach, William. *Land of desire: merchants, power, and the rise of a new American culture*. New York: Pantheon Books, 1993.
- Lears, T. J. Jackson. *Rebirth of a nation: the making of modern America, 1877-1920*. New York: Harper Collins, 2009.
- Lenoir, Timothy, Hans Ulrich Gumbrecht, and Ursula Klein. *Experiments, models, paper tools: cultures of organic chemistry in the nineteenth century*. Stanford, Calif.: Stanford University Press, 2003.
- Lindberg, David C. *Theories of vision from al-Kindi to Kepler*. Chicago: University of Chicago Press, 1981.
- Logan, Frederick M. *Growth of art in American schools*. New York: Harper, 1955.
- Mancini, JoAnne Marie. *Pre-Modernism: Art-World Change and American Culture from the Civil War to the Armory Show*. Princeton, N.J.: Princeton University Press, 2005.
- Marx, Leo. *The machine in the garden; technology and the pastoral ideal in America*. New York: Oxford University Press, 1964.
- McCaughey, Robert A. *Stand, Columbia: a history of Columbia University in the city of New York, 1754-2004*. New York: Columbia University Press, 2003.
- McCormmach, Russell, and Christa Jungnickel. *Intellectual mastery of nature*. Chicago: University of Chicago Press, 1986.
- Mills, A. A. "Newton’s Prisms and His Experiments on the Spectrum." *Notes and Records of the Royal Society of London* 36, no. 1 (1981): 13-36.

- Milton Bradley Company. *Milton Bradley, a successful man: a brief sketch of his career and the growth of the institution which he founded*. Boston: J. F. Tapley Co. 1910.
- Misa, Thomas J. *A nation of steel: the making of modern America, 1865-1925*. Johns Hopkins studies in the history of technology. Baltimore: Johns Hopkins University Press, 1995.
- Montgomery, David. *The fall of the house of labor: the workplace, the state, and American labor activism, 1865-1925*. Cambridge: Cambridge University Press, 1987.
- Morawski, Jill G. "Reflexivity and the psychologist." *History of the Human Sciences* 18, no. 4 (November 1, 2005): 77-105.
- Morawski, Jill G. *The Rise of Experimentation in American Psychology*. Yale University Press, 1988.
- Munsell, Albert Henry. *A color notation*. Boston: G. H. Ellis Co., 1905.
- . *Color and an eye to discern it*. s.n. S.l. :
- . "On the relation of the intensity of chromatic stimulus (physical saturation) to chromatic sensation." *Psychological Bulletin*. Vol. 6(7) 6, no. 7 (July 1909): 238-239.
- Murchison, Carl Allanmore, Edwin Garrigues Boring, and Gardner Lindzey. *A History of psychology in autobiography*. Washington, D.C.: American Psychological Association, 1930-1989.
- Musselman, Elizabeth Green. *Nervous Conditions: Science and the Body Politic in Early Industrial Britain*. Albany: SUNY Press, 2007.
- Noll, Mark A. *Princeton and the Republic, 1768-1822 : the search for a Christian Enlightenment in the era of Samuel Stanhope Smith*. Princeton, N.J.: Princeton University Press, 1989.
- Oakes, Clifton R. *Milton Bradley microform: an historical study of his educational endeavors in the context of the kindergarten movement in America*, 1975.
- Otter, Chris. *The Victorian eye: a political history of light and vision in Britain, 1800-1910*. Chicago: University of Chicago Press, 2008.
- Paclt, J. "A Chronology of Color Charts and Color Terminology for Naturalists." *Taxon* 32, no. 3 (1983): 393-405.

- Pastoureau, Michel. *Black: the history of a color*. English language. Princeton, N.J.: Princeton University Press, 2009.
- . *Blue: the history of a color*. Princeton, N.J.: Princeton University Press, 2001.
- Peter John Brownlee. "Ophthalmology, Popular Physiology, and the Market Revolution in Vision, 1800–1850." *Journal of the Early Republic* 28, no. 4 (2008): 597-626.
- Pool, Phoebe. *Impressionism*. New York: Praeger, 1967.
- Porter, Theodore M. *Trust in numbers: the pursuit of objectivity in science and public life*. Princeton, N.J.: Princeton University Press, 1995.
- Nettleship, Edward, William Thomson, and William Campbell Posey. *Diseases of the eye*. Philadelphia: Lea brothers & Co. 1900.
- Promey, Sally M. "The Ribband of Faith: George Inness, Color Theory, and the Swedenborgian Church." *American Art Journal* 26, no. 1/2 (1994): 45-65.
- Ratliff, Floyd. *Paul Signac and Color in Neo-Impressionism*. Rockefeller University Press, 1992.
- Richards, Robert J. *The romantic conception of life : science and philosophy in the age of Goethe*. Science and its conceptual foundations. Chicago: University of Chicago Press, 2002.
- Robinson, Edgar Eugene, and Milton S. Latham. "The Day Journal of Milton S. Latham." *California Historical Society Quarterly* 11, no. 1 (March 1, 1932): 2-28.
- Rothstein, William G. *American physicians in the nineteenth century: from sects to science*. Baltimore: Johns Hopkins University Press, 1972.
- Rudolph, John. "Turning Science to Account: Chicago and the General Science Movement in Secondary Education, 1905 - 1920." *Isis*, no. 96 (2005): 353-389.
- Sahlins, Marshall David. *Culture in practice: selected essays*. New York: Zone Books, 2000.
- Salisbury, Deb. *Elephant's Breath & London Smoke*. Five Rivers Chapmanry, 2009.
- Sandage, Scott A. *Born losers: a history of failure in America*. Cambridge, MA.: Harvard University Press, 2005.

- Saunders, Barbara. *The debate about colour naming in 19th century German philology :selected translations /*. Leuven: Leuven University Press,, c2007.
- Saunders, Barbara, and J. van Brakel. *Theories, technologies, instruments of color : anthropological and historiographic perspectives*. Lanham, MD: University Press of America, 2002.
- Schwarz, Andreas, and Rolf G Kuehni. *Color ordered : a survey of color order systems from antiquity to the present*. Oxford: Oxford University Press, 2008.
- Schweizer, Paul D. "John Constable, Rainbow Science, and English Color Theory." *The Art Bulletin* 64, no. 3 (1982): 424-445.
- Sepper, Dennis L. *Goethe contra Newton : polemics and the project for a new science of color*. Cambridge: Cambridge University Press, 1988.
- Shapiro, Alan E. "Artists' Colors and Newton's Colors." *Isis* 85, no. 4 (December 1, 1994): 600-630.
- . "The Evolving Structure of Newton's Theory of White Light and Color." *Isis* 71, no. 2 (June 1, 1980): 211-235.
- Shea, James J. *The Milton Bradley story*. New York: Newcomen Society in North America, 1973.
- Shea, James J. *It's all in the game*. New York: Putnam, 1960.
- Shenstone, W. A. *Justus Von Liebig, His Life and Work (1803-1873)*. New York: Macmillan, 1895.
- Sherman, Paul D. *Colour vision in the nineteenth century : the Young-Helmholtz-Maxwell theory*. Bristol: A. Hilger, 1981.
- Smith, Mark M. *Sensing the past : seeing, hearing, smelling, tasting, and touching in history*. Berkeley: University of California Press, 2007.
- Smith, Walter. *Art education : scholastic and industrial*. Boston: J. R. Osgood, 1873.
- Sobel, Robert. *The Big Board; a history of the New York stock market*. New York: Free Press, 1965.
- Sokal, Michael M, Bruce V Lewenstein, and Sally Gregory Kohlstedt. *The establishment of science in America : 150 years of the American Association for the Advancement of Science*. New Brunswick, N.J.: Rutgers University Press, 1999.

- Soucy, Donald, and Mary Ann Stankiewicz. *Framing the past : essays on art education*. Reston, Va.: National Art Education Association. 1990.
- Starr, Paul. *The social transformation of American medicine*. New York: Basic Books, 1982.
- Stevens, W. Le Conte. "Ogden N. Rood." *Science* 16, no. 414. (December 5, 1902): 881-884.
- Taussig, Michael T. *What color is the sacred?* Chicago: The University of Chicago Press, 2009.
- Taylor, William Bower. *A memoir of Joseph Henry: A sketch of his scientific work*. Washington: U.S. Govt. Print Off. 1880.
- Thompson, Emily Ann. *The soundscape of modernity: architectural acoustics and the culture of listening in America, 1900-1933*. MIT Press, 2004.
- Trachtenberg, Alan. *The incorporation of America : culture and society in the gilded age*. New York: Hill and Wang, 1982.
- Travis, Anthony S. *The rainbow makers : the origins of the synthetic dyestuffs industry in western Europe*. Bethlehem: Lehigh University Press, 1993.
- . "From Manchester to Massachusetts via Mulhouse: The Transatlantic Voyage of Aniline Black." *Technology and Culture* 35, no. 1 (January 1, 1994): 70-99.
- . "Perkin's Mauve: Ancestor of the Organic Chemical Industry." *Technology and Culture* 31, no. 1 (January 1, 1990): 51-82.
- . "Science's Powerful Companion: A. W. Hofmann's Investigation of Aniline Red and Its Derivatives." *The British Journal for the History of Science* 25, no. 1 (March 1, 1992): 27-44.
- Turner, R. Steven. *In the eye's mind : vision and the Helmholtz-Hering controversy*. Princeton, N.J.: Princeton University Press, 1994.
- . "Paradigms and Productivity: The Case of Physiological Optics, 1840-94." *Social Studies of Science* 17, no. 1 (February 1, 1987): 35-68.
- Warner, Charles Dudley, and Mark Twain. *The gilded age: a tale of to-day*. New York: Harper & Brothers, 1901.



- Warner, John Harley. *Against the spirit of system : the French impulse in nineteenth-century American medicine*. Princeton, NJ: Princeton University Press, 1998.
- . *The therapeutic perspective : medical practice, knowledge, and identity in America, 1820-1885*. Cambridge, MA.: Harvard University Press, 1986.
- Weingarden, Lauren S. "The Colors of Nature: Louis Sullivan's Architectural Polychromy and Nineteenth-Century Color Theory." *Winterthur Portfolio* 20, no. 4 (December 1, 1985): 243-260.
- Welke, Barbara Young. *Recasting American liberty : gender, race, law, and the railroad revolution, 1865-1920*. Cambridge: Cambridge University Press, 2001.
- Wiebe, Robert H. *The search for order, 1877-1920*. New York: Hill and Wang, 1967.
- Wilson, Daniel J. *Science, community, and the transformation of American philosophy, 1860-1930*. Chicago: University of Chicago Press, 1990.
- Wilson, Leonard G, and Elizabeth Harriet Thomson. *Benjamin Silliman and his circle: studies on the influence of Benjamin Silliman on science in America : prepared in honor of Elizabeth H. Thomson*. New York: Science History Publications, 1979.
- Wilson, R. J. *Darwinism and the American intellectual: a book of readings*. Homewood, Ill.: Dorsey Press, 1967.
- Woods, H. *The history of the Presbyterian controversy : with early sketches of Presbyterianism*. Louisville: N.H. White, 1843.
- Young, Thomas. *A course of lectures on natural philosophy and the mechanical arts*. London: Printed for J. Johnson, 1807.