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Actually and Think: Photography as a Local Color Language

Scientists in mid-twentieth century America replicated iconic early modern experiments to study color phenomenon. In 1959, Edwin Land, physicist and founder of Polaroid Land, repeated three steps of Isaac Newton's 1660s experiments with prisms; and in 1961, Ralph Evans, physicist and director of color technology at Eastman Kodak, recreated James Clerk Maxwell's 1861 first color photograph. Derivations of color photography played an integral experimental role in the measurement of light and color, as a tool of rhetoric and persuasion, and to express ideas at the forefront of scientific thought. Color was, in both eras, observed to be a primary phenomenon that was difficult to define or quantify. The interpreted results of the repeated experiments changed, clarifying the ways scientific knowledge about color was created. Color photography caused confusion about color phenomenon through its instrumental role within experimental physics, but it also was part of a language established to communicate the modern understanding of color. This language articulated a response to intractable problems and inherent difficulties by expressing peripheral and liminal aspects of color perception as photographs.

Land's 1959 article in *Scientific American,* «Experiments in Color Vision», was a key utterance to use photography within a local color language.[1] The construction of a color language was considered to be an initial difficulty for scientists as it inserted a sign or symbol into the immediacy of ordinary color experience.[2] Johann Wolfgang von Goethe warned in *Theory of Colors* (1810) «how difficult it is to avoid substituting the sign for the thing; how difficult to keep the essential quality still living before us, and not to kill it with the word.»[3] The «general idea» and «elementary state» of color was «rather hidden and obscured than elucidated and brought nearer to us»[4] in its expression within language. It was a sentiment echoed more broadly by Ludwig Wittgenstein adding that «between judgements that are in some way so close-lying to our perceptions that the insertion of a distance between what we perceive and what we judge is absurd.»[5] A modern color language would further need an ability to shift in meaning as color itself did. In this way, Land's work allied Newton's past studies with contemporary physicists, particularly Evans. It also overlapped with concurrent developments in experimental psychology, with Land's experiments referenced by Anton Ehrenzweig in *The Hidden Order of Art* (1966) and by James J. Gibson in *The Ecological Approach to Visual Perception* (1979).

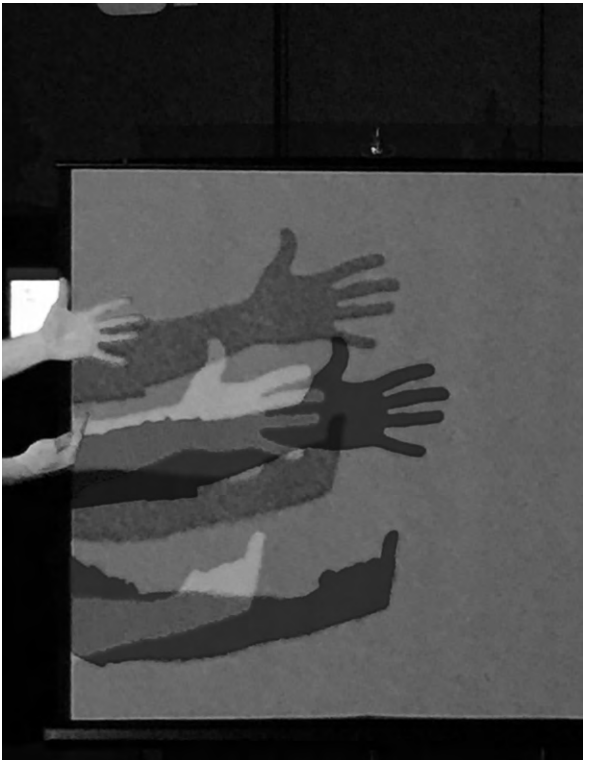
The mid-twentieth century understanding of color was predicated on knowledge embedded in three main subjects: physics, psychophysics and psychology.[6] Physics and psychology are «glued together in an intimate and enigmatic way»[7] with the result that «colour has been the most celebrated research topic in our attempt to understand the relationship of the physical and psychological, the objective and the subjective.»[8] Color photography had multiple, interdependent processes and functions that

were particular adaptations that fostered its ability to resist disciplinary stratification and positioned it as an instrument to analyze variations of color phenomenon. Physicists studied the physical properties of light as part of broader studies using light and color measurement technology. Meanwhile, psychologists used the results produced by physicists to study further distinctive qualities about color, including memory, visual perception and artistic imagination. Color photography was able to communicate the modern understanding of color across boundaries thereby allowing physicists and psychologists to establish a mode of color expression that also examined approaches to study color phenomenon. Within the photographs existed an act of self-destruction where, not only did long-held assumptions destabilize, but new meanings or understandings could be uncovered or created from within the images. In this way, color photographs marked both past and potential discoveries, particularly areas at the edge of scientific thought that needed further contemplation or probing.

In «Experiments in Color Vision», Land's opening image invited the readers to remember the pleasure and innate curiosity of viewing color, how «From childhood onward we enjoy the richness of color in the world around us.»[9] But, in this easy attention, he offered a warning. Color perception was selective and creative, making «colored worlds of its own out of informative materials that have always been supposed to be inherently drab and colorless.»[10] The modern era of color was founded in the fundamental knowledge gained when Newton refracted white light into distinct rays through a prism, then used a second prism to recombine the separated rays. The experimental methodology of physicists, therefore, was a determinative touchstone for studying color by scientists, but also artists and commercial manufacturers,[11] as it provided theoretical and physical laws, quantified units of measurement, and codified color terminology. In the theory of three-color vision, called by Land the ‹old theory›, there was a direct correlation between waves of light and color perception. Land concluded that this correspondence allowed for «a deeply satisfying logical basis.»[12] A realization of the experimental repetitions was that color photography had not played a passive instrumental role in reproducing or revealing actual invisible processes, and confirmed instead that results were an artifact of production that were revealed as flawed.[13]

Land's experiments [fig. 1/pl. 10] challenged this logical or physical connection to color perception through his repetition of one step in Newton's series of prism experiments, this time using the dye imbibition process, Flexichrome. The use of color photography as a demonstration apparatus[14] provided future experimenters a fixed, repeatable point to follow. Dye imbibition was the process of choice for scientific experimentation, and for artists and commercial photographers, as it allowed far greater control of color qualities, like tone, shade, and saturation.[15] Images were assembled in several parts: three black-and-white separation negatives or positives were exposed through green, red and blue filters, which created corresponding dye matrices in cyan, magenta and yellow that were finally layered onto a paper support.[16] An unexpected result ensued when Land modified Newton's experiment to include Flexichrome's black-and-white transparencies:

> There is, of course, no color in the photographs….A glance at the two shows that they are not absolutely identical. Some of the objects in the scene are represented by areas which are lighter in the first photograph than in the second. Others are darker in the first and lighter in the second. But all that either photograph can do is to pass more or less of the light falling on its different regions.[17]



1 Demonstration of Edwin Land's experiments in color vision, Summer Institute of Technical Studies in Art, Harvard Art Museums, June 2018.

When Land projected yellow light through these black-and-white transparencies, instead of viewing a mixture of two colors, the image changed to the full, but pale, color spectrum. Land, «forced to the astonishing conclusion», understood that light rays are not color-making but that: «they are bearers of information that the eye uses to assign appropriate colors to various objects in an image.»[18] Even when an image was created through a mixture of two yellow wavelengths of very subtle relative strengths and intensities, the image was still fully colored.[19] This understanding led Land to end his experiment with a question: if only two bands of color information are needed to allow for full color perception, what was the third band of information for?[20] The ‹old theory› was not wrong, Land added, perhaps hedging against his own theory's to-be-discovered oversights, «This long line of great investigators cannot have been mistaken.»[21] Land deduced that the ‹old theory› showed only one aspect of psychophysical color perception, the mix of colored spots on a colored surround. Instead, Land had studied for the last five years, color vision «under natural conditions in complete images.»[22] Land's color photographs disproved the original meaning of Newton's demonstration, though continued to use the display of color photography as a mimetic representation, now of this ‹new theory› of color perception.

Physicists expected that the accuracy of color measurement instrumentation would further prove the physical logic of the ‹old theory›, but in fact, Land's experiment showed that the subjective elements of color perception played a much more complex role in visualizing color. These findings were in keeping with the study of light and color measurement, which also followed a meandering and often

unacknowledged history as a result of its reliance on the subjectivity of observation and localized tools.[23] There arose a distinct class of instrumentation in the 1930s, research technologies[24] to measure light and color, that revealed to Land the minute differences in intensity between relative bands of color information to display a full color image. Some scientific methodologies worked to overcome disciplinary stratification by developing and communicating local languages as a way to extend thinking outside or beyond discrete disciplines.[25] Peripheral sciences[26] developed across different boundaries such as increments of measurement, theory and practice, and subject matter to form collaborative social, material and technical networks. This type of thought collective[27] was characterized through shared authority among non-specific practitioners; a defining interdependence across subject areas; and a moving or shifting interaction between technology, science and experimentation that resisted systematization and codification.[28] Language was localized between groups, and used modified and simplified forms of expression, ‹pidgins and creoles›.[29] Color photographs offered physicists and psychologists a shared form to arrange and construct overlapping or conflicting meanings between light and color measurements and color perception in natural conditions.[30]

Physicists and psychologists‘ construction of a language to express color phenomenon, however, led to the reassessment of certain procedures and methods. While the quantification of elements of color and light, reflected a continuation of the Newtonian method of measurement and didacticism, the impact and limits of the laboratory on the study of color phenomenon came under particular scrutiny. Land, Evans, and Gibson faulted the ‹old theory› methods and scope of psychophysics in lieu of studying color perception in natural conditions. Psychophysical reactions studied observers «prodded with controlled and systematically varied bits of energy,»[31] which confused scientists about the creative possibilities of color perception, as «Stimulus prods do not ordinarily carry information about the environment.»[32] The study of color perception occurring in natural conditions examined an action that could be directed and anticipated, as Gibson described it, «an act, not a response, an act of attention, not a triggered impression, an achievement, not a reflex.»[33]

Despite this evaluation of the methods and results of the ‹old theory›, color photography also seemed to be able to represent color perception in natural conditions. Land relied on Flexichrome to demonstrate his thesis of color vision. Color was part of a total field of vision with an interaction and tension between «two major factors which may be expressed loosely by the expressions ‹what you actually see› and ‹what you think you see.›»[34] Addressing the readers of *Introduction to Color* (1948), Evans described a simple experiment that could be repeated at home. He observed his changing viewpoints when looking at a window of his beach house from the porch, flowers were on a table just inside the house, and the ocean, behind him, was reflected in the window:

> If attention is directed entirely to the landscape or to the plant, the other nearly, but not quite, disappears…The third way of looking at the window gives a surprising result but is quite difficult. If attention is directed entirely to the surface of the window, and an attempt is made to see it as colored glass…for brief moments it can be seen that the orange of the blossom and the bluish green of the sea to a large extent neutralize each other and appear almost, but not quite, gray.[35]

Evans composed a three-layered image to be imagined or remade by the reader, an effect evoked in Eliot Porter’s photograph «Boat Shop Window and Fireweed, Great

2 Eliot Porter, Boat Shop Window and Fireweed, Great Spruce Head Island, Maine, 1972, Dye imbibition print, Amon Carter Museum of American Art, Fort Worth, Texas.

Spruce Head Island, Maine» (1972) [fig. 2/pl. 11]. The photograph arranged color in the environment as an aggregate and conglomerate of substances and surfaces, where edges and corners, convexities and concavities, were formative to color perception.[36] Colors were perceived to be obscured, lost, revealed and imagined.

Color occurred in part through ‹total syncretistic vision› based on movement between unconscious scanning and conscious detecting within an environment, a form of perception «more acute in scanning complex structures,»[37] like color. Syncretistic vision allowed people to «*sense* the environment…in the meaning of *detecting.*»[38] Colorful things were perceived «with equal impartiality, insignificant as they may look to normal vision,»[39] moving flexibly between different modes of conscious and unconscious thinking,[40] with the result that syncretistic vision «balances one distortion against the other and extracts a common denominator or fulcrum.»[41] Jeanette Klute, lead research color photographer at Kodak who illustrated Evans's lectures and publications, including *Introduction to Color,* described this act of scanning and detecting color in *Woodland Portraits* (1950):

> Many times when I walk into the woods it seems like an impenetrable mass of greenness, but gradually as I become attuned to the spirit of the woods this greenness gives way to a miracle of individual colors and sensations. I begin to see light coming through the pale pink petal of a flower, the sparkle on a frog's wet green back, the whiteness of a trillium against a gray tree trunk, a raccoon's footprint in the dark brown mud, the soft green light as it comes through the trees, or the redness of a freshly fallen leaf. [42]

Color perception oscillated between different realities of seeing «so that it is possible to shift from one to another voluntarily.»[43] Evans, Porter, Klute and Land represented color as part of an arrangement, not an absolute, formed and perceived

together through time, and «relative to the color of adjacent surfaces.»[44] In this type of perception, it is possible to «combine the ambiguity of dreaming with the tensions of being fully awake. In the moment of inspiration, reality will appear… super-real and intensely plastic.»[45]

The tearing apart of the logical correlation between three-color vision and three-color photography, intrinsic to the accepted interpretation of the images produced, and the replacement with an ecological, syncretistic structure of perception, recreated the methodological and expressive contributions of the ‹old theory› photographs. In 1961, Evans repeated Maxwell and illustrator Thomas Sutton's first demonstration of three-color vision using a color photograph. Sutton's photograph, which Evans later studied, depicted a tartan ribbon formed through the projection of three different color negatives. It was exhibited in a public demonstration at the Royal Institution of Great Britain on May 17th, 1861. Evans discovered the image was technically impossible as the emulsions at the time were insensitive to the colors Maxwell and Sutton thought they had produced.[46] Evans studied this technical marvel finding various explanations, including that the red plate had in fact been sensitive to ultraviolet light, while the green plate was the result of a concentrated blue-green solution of cupric chloride. Evans's repetition of Maxwell's experiment confirmed the folly of understanding any photograph mimetically, with Ehrenzweig adding that for artists «no analytic matching dot by dot, brush stroke by brush stroke, can ‹match› its colours against specific perceptions.»[47]

Color photography functioned, instead, as a type of creative utterance[48] to be discovered within the dissemblance of the logical meaning. Artistic imagination, as Ehrenzweig argued, was formed in the oscillation between conscious and unconscious thought of syncretistic vision, between ‹actually› and ‹think.› Maxwell and Sutton's 1861 impossible photograph always existed at an outer edge, beginning as a thought experiment in 1855, when Maxwell described in a letter a possible proof of the theory of three-color vision, «from the art of photography.» The described photograph would record «the colours of a landscape, by means of impressions taken on a preparation equally sensitive to rays of every colour.»[49] Maxwell, acknowledging it existed only in concept, imagined a future photograph where a plate of red glass was placed before the camera, then green and violet. A full spectrum colored image would be displayed when the three exposures were projected through a magic lantern.[50] The described photograph nebulously marked Maxwell's active thinking and engagement of his imagination, an outgrowth of syncretistic vision where «the creative thinker is capable of alternating between differentiated and undifferentiated modes of thinking….»[51] Evans's exposure of the unknown factors destroyed the logical meaning of the photograph and confirmed, instead, that Maxwell's iterations described acts of creation at the limits of scientific knowledge.

Certain images[52] worked to express «events within the creative personality» and were able to «describe the act of creating» by bringing together «many levels.»[53] 'Poemagogic' imagery appeared self-destructive by «casting aside sharply crystallized modes of rational thought and image making.» Maxwell's use of a photographic image to symbolize the act of creation originated in a still earlier series of experiments by William Henry Fox Talbot recorded in *The Pencil of Nature* (1844).[54] Fascicle VIII, «A Scene in a Library,» was composed as a description of actual photographic experiments, a description of an imagined photographic experiment, and a photograph. Talbot described how Thomas Young and a German scientist named

Ritter, as part of studies into three-color vision, had used photo-chemistry «in a curious experiment or speculation»[55] to observe invisible violet light. Talbot, first describing Newton's prism experiments, added: «Experimenters have found that if this spectrum is thrown upon a sheet of sensitive paper, the violet end of it produces the principal effect: and, what is truly remarkable, a similar effect is produced by certain *invisible rays* which lie beyond the violet.»[56] Talbot proposed an imagined photographic experiment, where an aperture would direct these invisible rays into an otherwise dark room and take portraits of those in the room.[57] Talbot's actual photograph did not conform in meaning either to the actual or imagined descriptions of experiments into invisible rays. Instead, Talbot included a photograph of a close-up of an almost impenetrable wall of books -- a wall of words -- with a small opening formed between a few books collapsed against each other. In the small void, the photographic image was positioned to provoke scientific imagination to move through or beyond.

The logical, if mistaken, meaning established between the ‹old theory› of color vision and color photography was in part simply replaced in mid-twentieth century America by a new theory of color perception illustrated with dye imbibition photographs. Nevertheless, the discoveries arising from these new theories, no matter how flawed they may ultimately be found to be as Land worried, established color photography as a transforming language where color phenomenon could be probed and shared across physics and psychology, and time. The construction of this mutating, local language upended the physical structure underpinning color phenomenon, and, instead, engendered aspects of perception that found color hidden, around corners, and in the convexes of an image. In this theory of color perception, photographs symbolized the movement between conscious and unconscious thinking, or ‹actually and think›, connecting the study of color phenomenon with the construction of scientific thought. Color photographs expressed, and inspired, the forefront of scientific thought on color phenomenon through iterative collaborations, where images were formed in concomitant acts that were actual and imagined, self-destructive and creative.

Notes

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2 *Colour Perception: Mind and the Physical World,* ed. by R. Mausfeld a. D. Heyer, Oxford 2003, p. vi.
3 Johann Wolfgang von Goethe, *Theory of Colors,* trans. by Charles Locke Eastlake, 1840, p. 302.
4 Ibid.
5 Ludwig Wittgenstein, *Philosophical Investigations,* trans. by Gertrude E. M. Anscombe, New York 1958, par. 24.
6 Ralph Evans, *An Introduction to Color,* New York 1948, p. v.
7 Mausfeld a. Heyer 2003 (as note 2), p. vi.
8 Ibid.
9 Edwin H. Land, Experiments in Color Vision, in: *Scientific American,* Vol. 200, No. 5 (May 1959), p. 84.
10 Ibid.
11 Ibid.
12 Ibid.
13 W. D. Hackmann, Scientific Instruments: Models of Brass and Aids to Discovery, in: *Uses of Experiment: Studies in Natural Sciences,* ed. by David Gooding, Trevor Pinch, Simon Schaffer, Cambridge 1989, p. 37.
14 Ibid.
15 Sylvie Penichon, *Twentieth Century Color Photographs: Identification and Care,* Los Angeles 2013, p.126.
16 Ibid.
17 Land 1959 (as note 9), p. 84.
18 Ibid.
19 Ibid, p. 87.
20 Land 1959 (as note 9), p. 96.
21 Ibid, p. 87.
22 Ibid.
23 Johnston 2001 (as note 1), p. 8.
24 Ibid.
25 *Picturing Science, Producing Art,* ed. by Caroline A. Jones a. Peter Galison with Amy Slaton, New York 1998, p. 1.
26 Johnston 2001 (as note 1), p. 9.
27 Ludwik Fleck, *Genesis and Development of a Scientific Fact,* trans. by Fred Bradley a. Thaddeus J. Trenn, ed. by Thaddeus J. Trenn a. Robert K. Merton, Chicago 1979, p. 4.
28 Johnston 2001 (as note 1), p. 9.
29 Ibid.
30 Fleck 1979 (as note 27), p. 4.
31 James J. Gibson, *The Ecological Approach to Visual Perception,* New York 1979, kindle edition, n. p.
32 Gibson 1979 (as note 31), n. p.
33 Ibid.
34 Evans 1948 (as note 6), p. 3.
35 Ibid.
36 Gibson 1979 (as note 31), n. p.
37 Anton Ehrenzweig, *The Hidden Order of Art: A Study in the Psychology of Artistic Imagination,* Berkley/Los Angeles, CA 1967, p. 8.
38 Gibson 1979 (as note 31), n. p.
39 Ehrenzweig 1967 (as note 37), p. 8.
40 Ibid.
41 Ibid, p. 9.
42 Jeannette Klute, Author's Note, in: *Woodland Portraits,* Rochester, n. p.
43 Evans 1948 (as note 6), p. 3.
44 Gibson 1979 (as note 31), n. p.
45 Ehrenzweig 1967 (as note 37), p. 12.
46 Paul D. Sherman, *Colour Vision in the Nineteenth Century: The Young-Helmholtz-Maxwell Theory,* Bristol 1981, p. 153.
47 Ehrenzweig 1967 (as note 37), p. 112.
48 See Gerald Holton, *Thematic Origins of Scientific Thought: Kepler to Einstein,* Cambridge 1973; Gerald Holton, *The Scientific Imagination: Case Studies,* Cambridge 1978.
49 James Clerk Maxwell, *On the Theory of Colours in relation to Colour-Blindness.* A letter to Dr G. Wilson, From the *Transactions of the Royal Scottish Society of Arts,* VOL. IV. Part III, p. 137.
50 Ibid.
51 Ehrenzweig 1967 (as note 37), p. xiii.
52 See Sir James George Fraser, *The Golden Bough: Studies in Magic and Religion,* Oxford 1994; Marion Milner (pseudonym Joannaa Field), *An Experiment in Leisure,* London 1937.
53 Ehrenzweig 1967 (as note 37), p. xiv.
54 Carol Armstrong, *Scenes in a Library: Reading the Photograph in the Book, 1843–1875,* Cambridge 1998, p. 215.
55 William Henry Fox Talbot, *Pencil of Nature,* London, Plate VIII.
56 Ibid.
57 Ibid, 30.