5 *Color and Information*

IN representing and communicating information, how are we to benefit from color's great dominion? Human eyes are exquisitely sensitive to color variations: a trained colorist can distinguish among 1,000,000 colors at least when tested under contrived conditions of pairwise comparison. Some 20,000 colors are accessible to many viewers, with the constraints for practical applications set by the early limits of human visual memory rather than the capacity to discriminate locally between adjacent tints. For encoding abstract information, however, more than 20 or 30 colors frequently produce not diminishing but negative returns.

Tying color to information is as elementary and straightforward as color technique in art, "To paint well is simply this: to put the right color in the right place," in Paul Klee's ironic prescription.[1] The often scant benefits derived from coloring data indicate that even putting a good color in a good place is a complex matter. Indeed, so difficult and subtle that avoiding catastrophe becomes the first principle in bringing color to information: *Above all, do no harm.*

[1] Paul Klee, *Notebooks: The Thinking Eye,* translated by Ralph Manheim (London, 1961; Basel, 1956), volume I, p. 39, n. 1.

AT work in this fine Swiss mountain map are the fundamental uses of color in information design: *to label* (color as noun), *to measure* (color as quantity), to *represent or imitate reality* (color as representation), and to *enliven or decorate* (color as beauty). Here color *labels* by distinguishing water from stone and glacier from field, *measures* by indicating altitude with contour and rate of change by darkening, *imitates reality* with river blues and shadow hachures, and visually *enlivens* the topography quite beyond what could be done in black and white alone.

Note the many finely crafted details: changes in the color of contour lines as the background shifts, interplay of light and shadow in areas of glacial activity, and color typography. The black-ink-only area at the bottom, though not an optimized monochrome design, gives a sense of the overwhelming informational benefits of color, when it is at its best.

Matterhorn, Landeskarte der Schweiz, 1347, Bundesamt für Landestopographie (Wabern, 1983), scale 1:25,000.

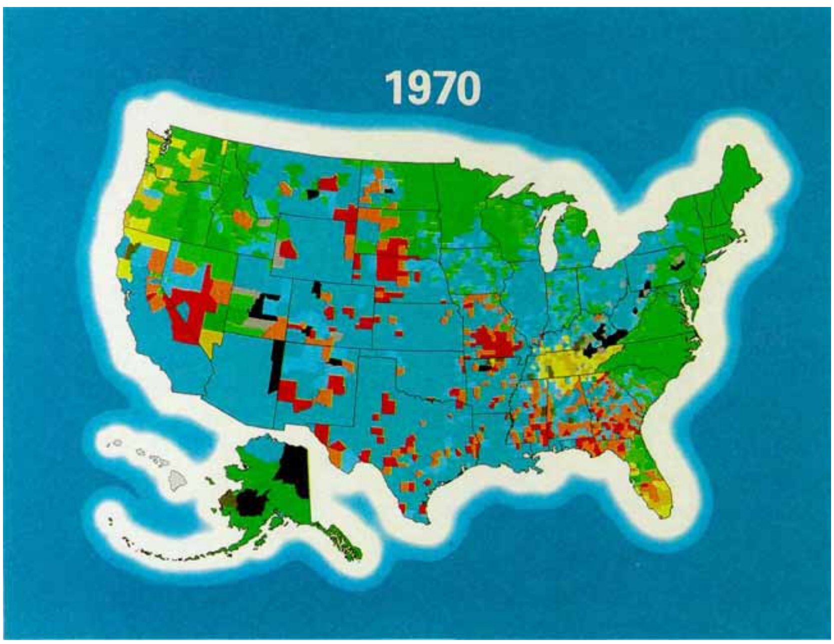
The Swiss maps are excellent because they are *governed by good ideas and executed with superb craft.* Ideas not only guide work, but also help defend our designs (by providing *reasons* for choices) against arbitrary taste preferences. Strategies for how color can serve information are set out in Eduard Imhof's classic *Cartographic Relief Presentation,* which describes the design practices for the Swiss maps. The first two principles seek to minimize color damage:

> *First rule:* Pure, bright or very strong colors have loud, unbearable effects when they stand unrelieved over large areas adjacent to each other, but extraordinary effects can be achieved when they are used sparingly on or between dull background tones. "Noise is not music. Only a piano allows a crescendo and then a forte, and only on a quiet background can a colorful theme be constructed." The organization of the earth's surface facilitates graphic solutions of this type in maps. Extremes of any type - such as highest land zones and deepest sea troughs, temperature maxima and minima - generally enclose small areas only. If one limits strong, heavy, rich, and solid colors to the small areas of extremes, then expressive and beautiful patterns occur. If one gives all, especially large areas, glaring, rich colors, the pictures have brilliant, disordered, confusing and unpleasant effects.

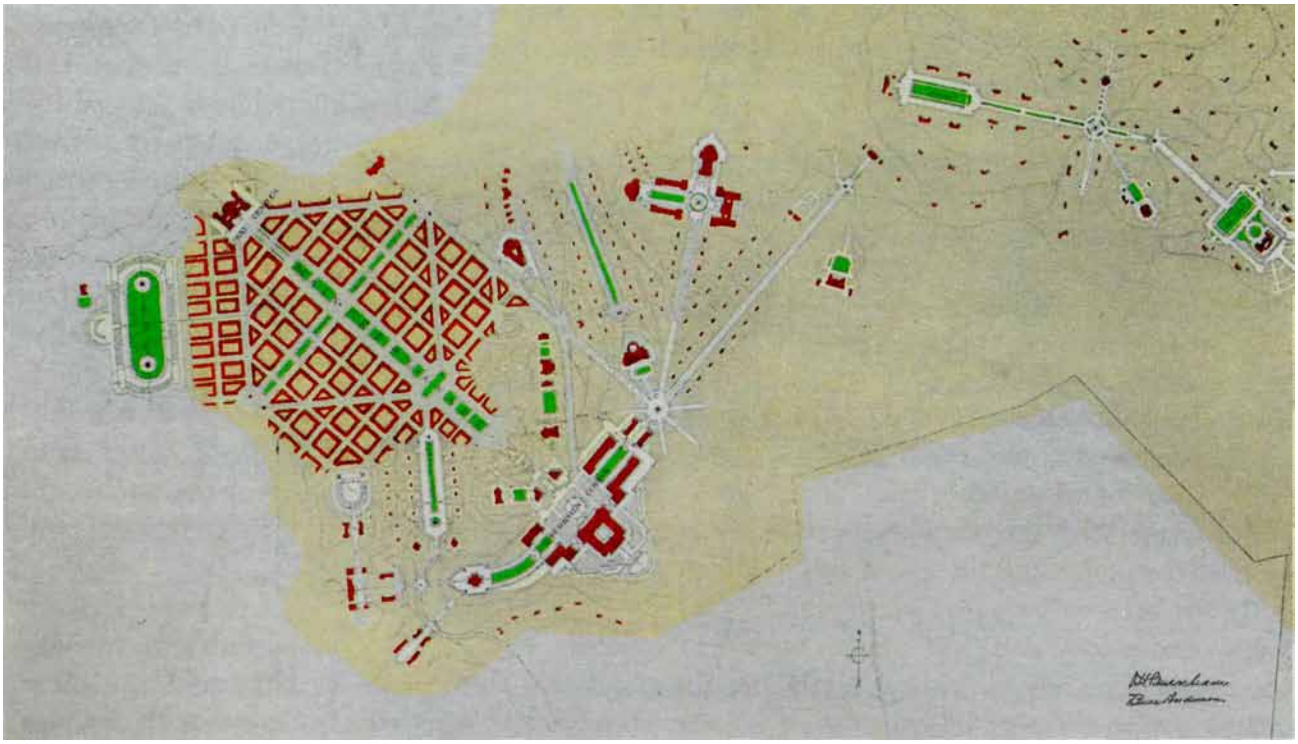
> *Second rule:* The placing of light, bright colors mixed with white next to each other usually produces unpleasant results, especially if the colors are used for large areas.[2]

[2] Note the after-images and vibration resulting from these strong colors (complementary, equal in value), an example from Josef Albers, *The Interaction of Color* (New Haven, 1963), "Vibrating Boundaries," folder XXII-I. The quotation is part of a longer list of color principles in Eduard Imhof, *Cartographic Relief Presentation* (Berlin, 1982), edited and translated by H.J. Steward from Imhof's *Kartographische Geländedarstellung* (Berlin, 1965), p. 72. The internal quotation is from H. Windisch, *Schule der Farbenphotographie* (Seebruck, 6th edition, 1958). The color logic is similar to that for emphasis in music: "Without accent there is no life. The beat becomes monotonous and wearisome. Music without accent lacks coherence, and movement becomes aimless where there is no impulse. Conversely, if every note, word or movement is stressed, the result has even less meaning." Ann Driver, *Music and Movement* (London, 1936), p. 34.

Violation of this counsel yields the exuberantly bad example below. All this strong color, especially the surrounding blue, generates a strange puffy white band, making it the map's dominant visual statement, with some alarming shapes at lower left. These colors are dark in value, and inevitably we have significant 1 + 1 = 3 effects again, at visual war with the heavily encoded information.



"Primary Home Heating Fuel, by Counties of the United States: 1950, 1960, 1970," GE-70, Bureau of the Census, United States Department of Commerce (Washington, D.C., n.d.). This series of maps also includes first-rate efforts, including the well-known "flashlight map" of population density.



Daniel H. Burnham, "Plan for a Summer Capital of the Philippine Islands, at Baguio," in Daniel H. Burnham and Edward H. Bennett, edited by Charles Moore, *Plan of Chicago* (Chicago, 1909), p. 28.

Along with its critique of color-clutter, Imhof's first rule contains an important constructive idea: *color spots against a light gray or muted field highlight and italicize data, and also help to weave an overall harmony*. Daniel Burnham's architectural drawing shows the vitality of small color spots on large muted backgrounds: coherent, vivid and textured but without clutter, the right color in the right place. The 1909 *Plan of Chicago* contains several other drawings the equal of that shown here — with skillful color illuminating architectural drawings and maps.

Applying a single mark, a strong but transparent spot, Jan Tschichold labels his rejection of the classical central axis typography and design, in favor of the asymmetric layout at right.

Jan Tschichold, *Die Neue Typographie* (Berlin, 1928), pp. 214-215. Redrawn.

COLOR serves as a label most nobly of all in Oliver Byrne's 1847 edition of Euclid's *Geometry*. This truly visual Euclid discards the letter-coding native to geometry texts. In a proof, each element names itself by consistent shape, color, and orientation; instead of talking about angle DEF, the angle is *shown* — appropriately enough for geometry. Below, we see an orthodox march through the Pythagorean theorem; too much time must be spent puzzling over an alphabetic macaroni of 63 encoded links between diagram and proof. At far right, the visual Pythagoras. Ruari McLean described Byrne's book as "one of the oddest and most beautiful books of the whole [19th] century ... a decided complication of Euclid, but a triumph for Charles Whittingham [the printer]."[3] A close look, however, indicates that Byrne's design clarifies the overly indirect and complicated Euclid, at least for certain readers.[4]

THEOREM 27. (Pythagoras' Theorem.)

In any right-angled triangle, the square on the hypotenuse is equal to the sum of the squares on the sides containing the right angle.

Given ∠BAC is a right angle.

To prove the square on BC = the square on BA + the square on AC.

Let ABHK, ACMN, BCPQ be the squares on AB, AC, BC.

Join CH, AQ. Through A, draw AXY parallel to BQ, cutting BC, QP at X, Y.

Since ∠BAC and ∠BAK are right angles, KA and AC are in the same straight line.

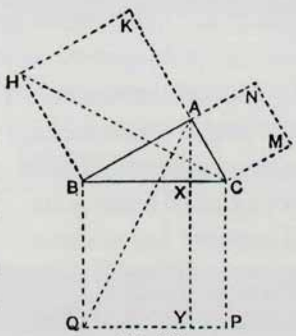


FIG. 163.

Again ∠HBA = 90° = ∠QBC.

Add to each ∠ABC, ∴ ∠HBC = ∠ABQ.

In the △s HBC, ABQ.

HB = AB, sides of square.

CB = QB, sides of square.

∠HBC = ∠ABQ, proved.

∴ △HBC ≡ △ABQ (2 sides, inc. angle).

Now △HBC and square HA are on the same base HB and between the same parallels HB, KAC;

∴ △HBC = ½ square HA.

Also △ABQ and rectangle BQYX are on the same base BQ and between the same parallels BQ, AXY.

∴ △ABQ = ½ rect. BQYX.

∴ square HA = rect. BQYX.

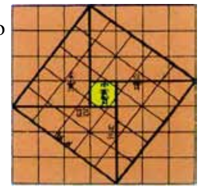
Similarly, by joining AP, BM, it can be shown that square MA = rect. CPYX;

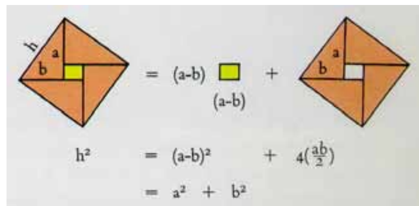
∴ square HA + square MA = rect. BQYX + rect. CPYX = square BP. Q.E.D.

C. V. Durell, *Elementary Geometry* (London, 1936), p. 119. For redesign of Durell's page in Gill Sans, see Peggy Lang, "Interpretative Typography Applied to School Geometry," *Typography*, 3 (Summer 1937); and Grant Shipcott, *Typographical Periodicals Between the Wars: A Critique of The Fleuron, Signature and Typography* (Oxford, 1980), p. 65.

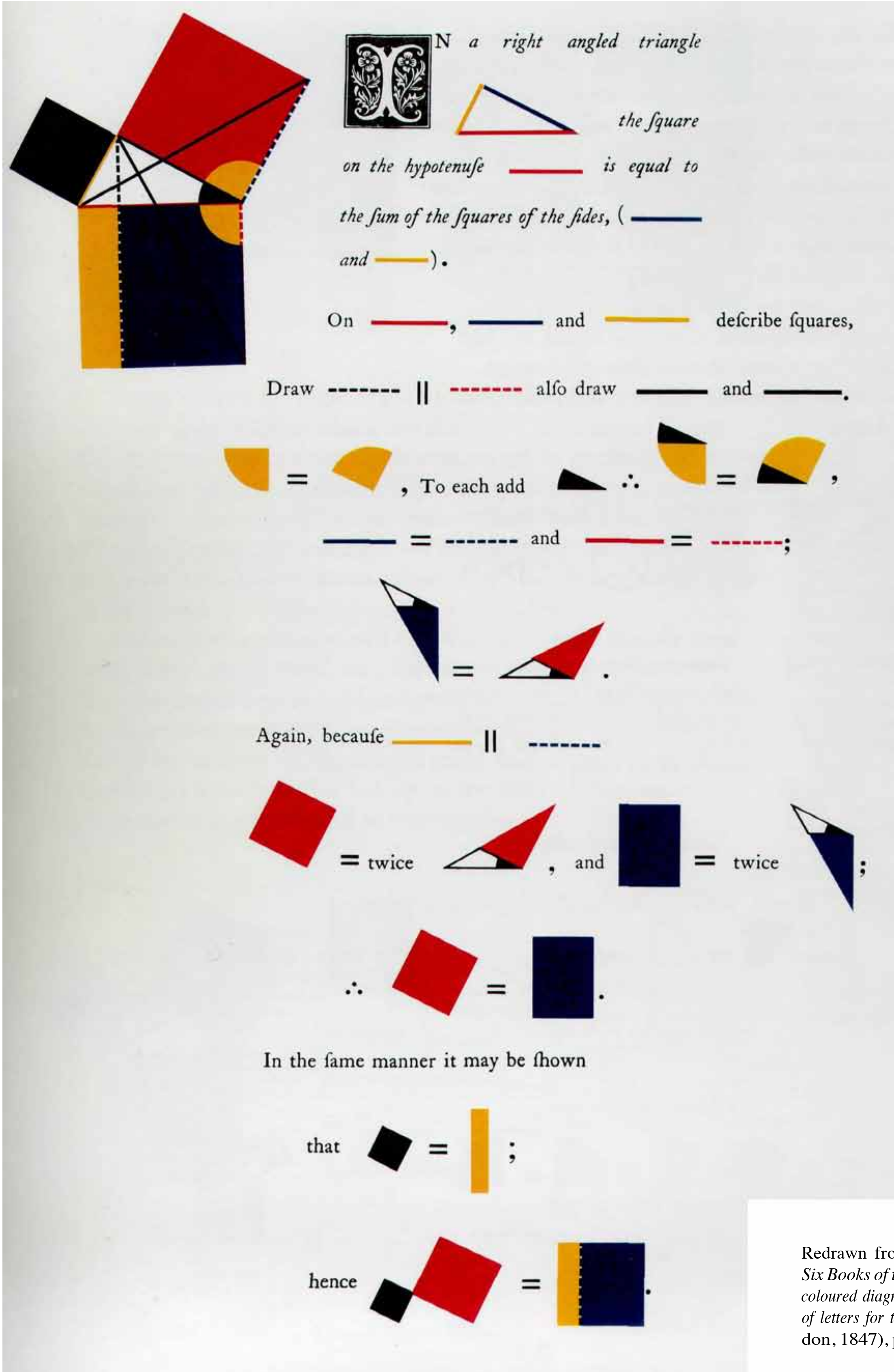
[3] Ruari McLean, *Victorian Book Design and Colour Printing* (New York, 1963), p. 51. See also Ruari McLean, *A Book is Not a Book* (Denver: University of Denver Graduate School of Librarianship, 1974).

[4] The classical Chinese mathematics book, the *Chou Pei Suan Ching* (ca -600 to +300), used but a single diagram for proof of the "Pythagorean" theorem. According to Needham, "in the time of Liu and Chao [ca +200], it was coloured, the small central square being yellow and the surrounding rectangles red." [Joseph Needham with Wang Ling, *Science and Civilisation in China: Mathematics and the Sciences of the Heavens and the Earth* (Cambridge, 1959), volume 3, pp. 22-23, 95-97.] The logic is





immediate, unlike the notoriously circuitous Euclid (Schopenhauer, *Sämmtliche Werke*, I. §15, described Euclid's Pythagoras as "a proof walking on stilts, nay, a mean, underhand proof"). And, pleasingly, Heath declares that the Chinese proof has "no specifically Greek colouring." [Thomas L. Heath, *Euclid: The Thirteen Books of the Elements* (Cambridge, 1926), volume I, p. 355.] See also the very special collection of 367 proofs, Elisha S. Loomis, *The Pythagorean Proposition* (Ann Arbor, 1940).



IN *a right angled triangle* *the ſquare on the hypotenuſe* *is equal to the ſum of the ſquares of the ſides,* (*and*).

On , and deſcribe ſquares,

Draw || alſo draw and .

= , To each add ∴ = ,

= and = ;

= .

Again, becauſe ||

= twice , and = twice ;

∴ = .

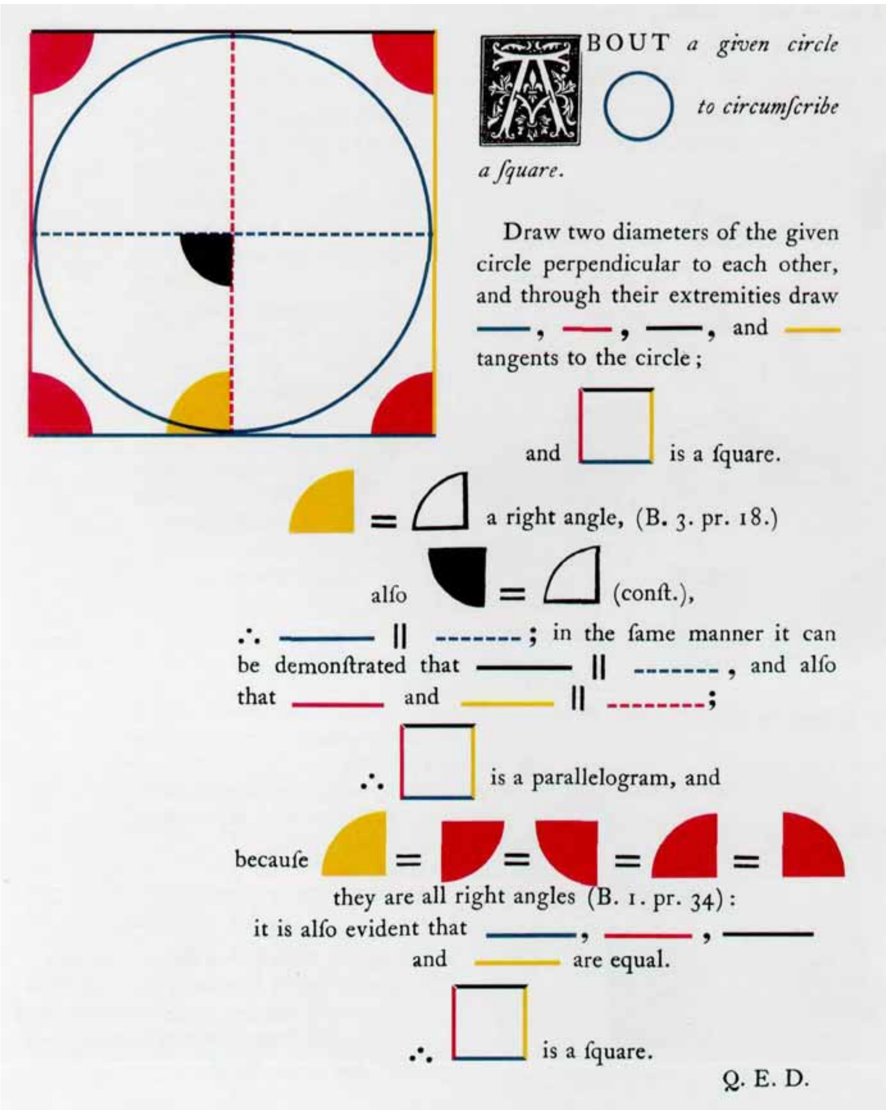
In the ſame manner it may be ſhown

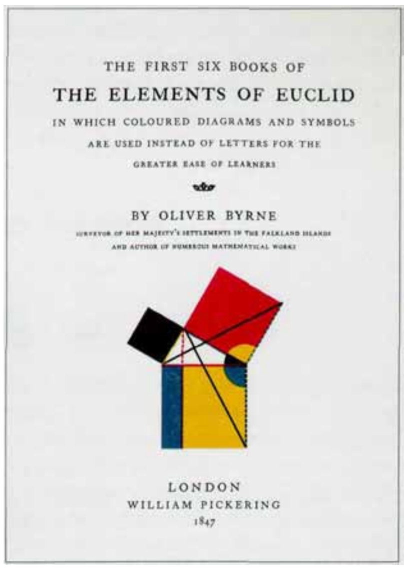
that = ;

hence = .

Redrawn from Oliver Byrne, *The First Six Books of the Elements of Euclid in which coloured diagrams and symbols are used instead of letters for the greater ease of learners* (London, 1847), pp. 48-49.

Below, instructions for circumscribing a square on a circle, with a typically roundabout Euclidean proof verifying that really is square. Byrne's colors keep in mind the knowledge to be communicated, color *for* information. Use of the primary colors and black provides maximum differentiation (no four colors differ more). This yellow, broken with orange, is darkened in value, sharpening the definition of its edge against white paper; and the blue is relatively light (on a value scale of blues), reinforcing its distance from black. In the diagrams, the least-used color is black, and it is carefully avoided for large, solid elements — adding to the overall coherence of the proofs by muting unnecessary contrasts. Spacious leading of type assists integration of text and figure, and also unifies the page by creating *lines* of type (instead of the solid masses usually formed by bodies of straight text) similar in visual presence to the geometric lines and shapes.




THE FIRST SIX BOOKS OF

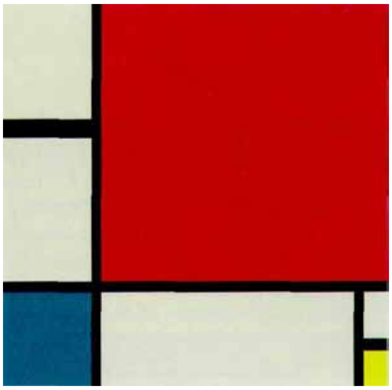
THE ELEMENTS OF EUCLID

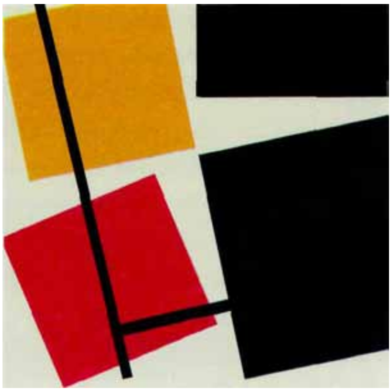
IN WHICH COLOURED DIAGRAMS AND SYMBOLS ARE USED INSTEAD OF LETTERS FOR THE GREATER EASE OF LEARNERS

BY OLIVER BYRNE

SURVEYOR OF HER MAJESTY'S SETTLEMENTS IN THE FALKLAND ISLANDS AND AUTHOR OF NUMEROUS MATHEMATICAL WORKS

LONDON
WILLIAM PICKERING
1847



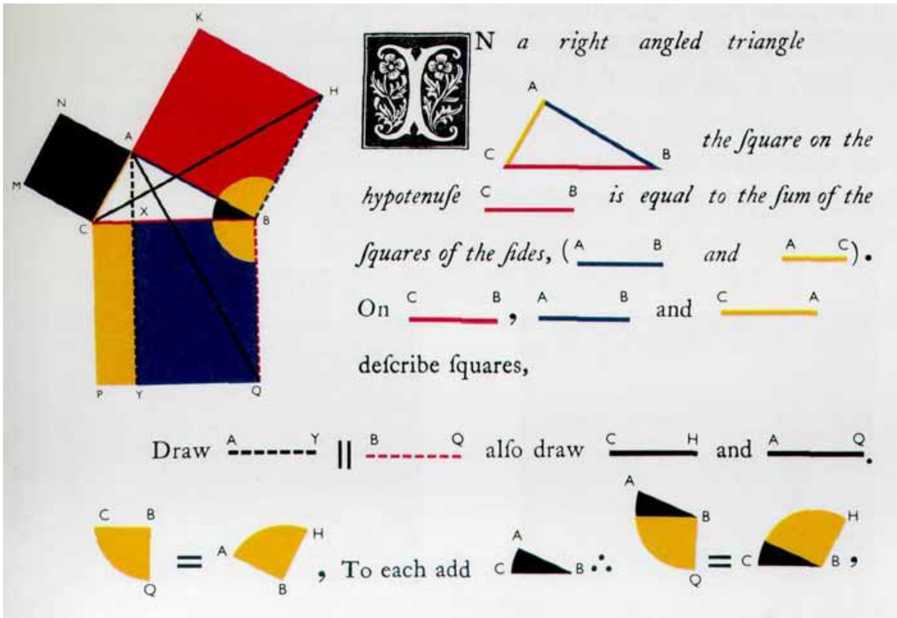


Piet Mondrian, *Composition with Red, Yellow and Blue,* 1930.

Theo van Doesburg, *Simultaneous Counter-Composition,* 1929-1930.

Design of these 292 pages of Euclid — drawn in 1847 by Her Majesty's surveyor of the Falkland Islands and also school mathematics teacher, Oliver Byrne — anticipates the pure primary colors, asymmetrical layout, angularity, lightness of plentiful empty space, and non-representational (abstract, "denaturalized") shapes characteristic of 20th-century Neo-Plasticism and De Stijl painting.[5] *And it is Euclid, too.* Only the decorative initial capital letters (wood-engraved by Mary Byfield) appear now as pre-modern . . . or, for that matter, post-modern.

This redrawing below of part of Pythagoras couples Byrne's visual method with conventional letter-encoding. Deflecting the fussiness that often results from redundant signals, the intermingling here of two labeling techniques seems to speed recognition of geometric elements as the eye moves between diagram and proof. Such a combination allows viewers to choose how they link up the text with the diagram, and it is likely that both methods will be used together.

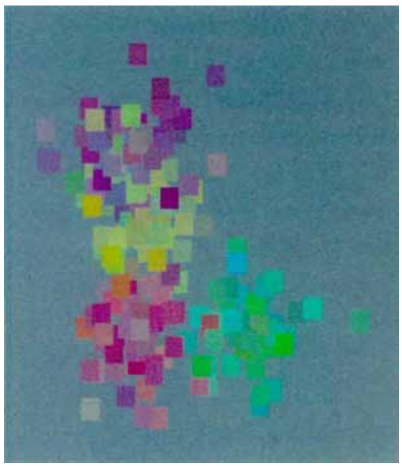


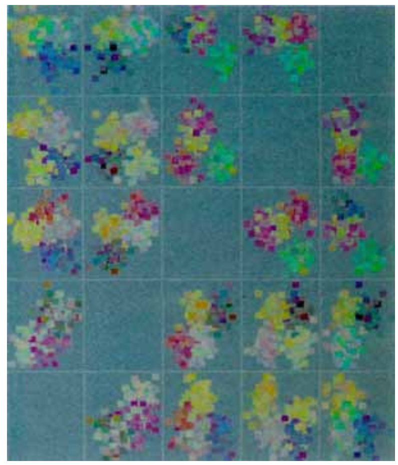
5 Piet Mondrian presented principles of Neo-Plasticism in 1926: "(1) The plastic medium should be the flat plane or the rectangular prism in primary colors (red, blue, and yellow) and in non-color (white, black, and gray) ... (2) There must be an equivalence of plastic means. Different in size and color, they should nevertheless have equal value. In general, equilibrium involves a large uncolored surface or an empty space, and a rather small colored surface. . . . (4) Abiding equilibrium is achieved through opposition and is expressed by the straight line (limit of the plastic means) in its principal opposition, i.e., the right angle. . . . (6) All symmetry shall be excluded." One version of the essay, "Home-Street-City," is found in Michel Seuphor, *Piet Mondrian: Life and Work* (New York, 1956), 166-168; see also *The New Art - The New Life: The Collected Writings of Piet Mondrian,* edited and translated by Harry Holtzman and Martin S. James (Boston, 1986), 205-212.

IN all 50 or so systems of color organization, every color is located in three space: described by *hue, saturation, and value* in Munsell and other spatial-perceptual classifications; by *red, green, and blue* components in various additive methods for video displays; and by *cyan, magenta, and yellow* components in subtractive methods for printing inks. A variety of color systems, but always three dimensions.

Colin Ware and John C. Beatty, "Using Color as a Tool in Discrete Data Analysis," Computer Science Department, University of Waterloo, report 05-85-21 (August 1985); and "Using Color Dimensions to Display Data Dimensions," *Human Factors*, 30 (1988), 127-142. Success is reported for locating simple clusters of data. For serious data analysis the method depends on how well viewers can visualize a particular color as a three-dimensional location.

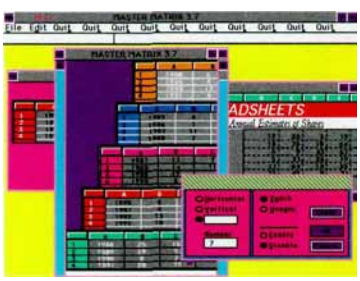
Can color's inherently multidimensional quality be used to express multidimensional information? And can viewers understand, or learn to understand, such displays? A good place to start on a video display terminal is to spread data-points over flatland for two dimensions and then light up each point by red, green, and blue (RGB) components,

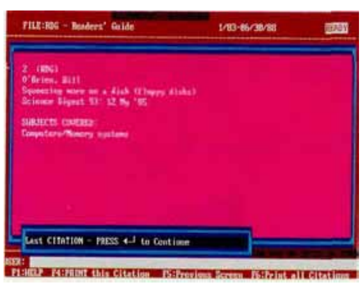


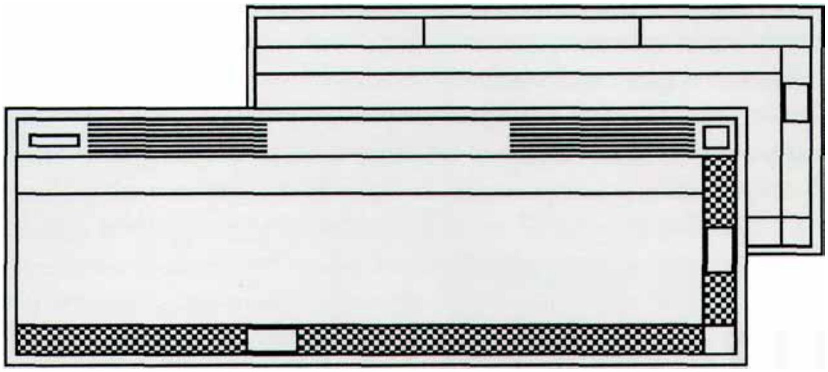


in proportion to values taken by three additional variables. At right, a five-by-five scatterplot matrix shows all X-Y pairs. Note color clusters of data, assemblies of three-dimensional similarity (on RGB variables) spread on the X-Y plane, an obvious improvement over black-only dots.

Color's multidimensionality can also enliven and inform what users must face at computer terminals, although some color applied to display screens has made what should be a straight-forward tool into something that looks like a grim parody of a video game:

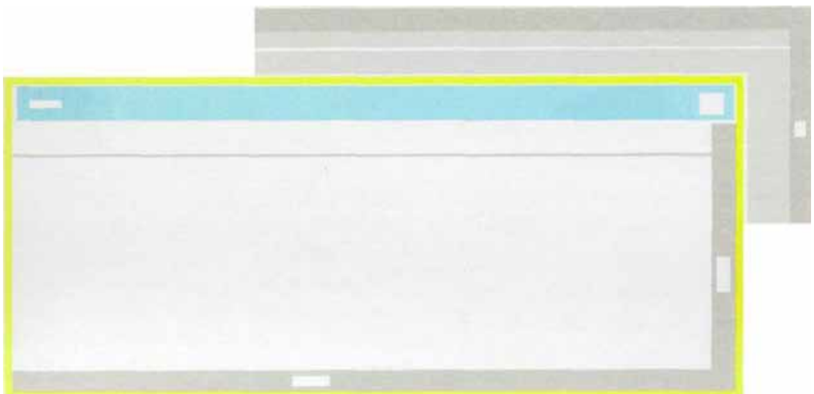






Shown above are conventional graphical interfaces, with scroll bars, multiple windows, and computer administrative debris. Closely-spaced, dark grid lines generate 1 + 1 = 3 clutter, with noise growing from the overscan borders (the surrounding dead area of a video tube). Noise is costly, since computer displays are low-resolution devices, working at extremely thin data densities, 1/10 to 1/1000 of a map or book page. This reflects the essential dilemma of a computer display: at every screen are two powerful information-processing capabilities, human and computer. Yet all communication between the two must pass through the low-resolution, narrow-band video display terminal, which chokes off fast, precise, and complex communication.

Color can improve the information resolution of a computer screen.[6] First, by softening the bright-white background, color calms video glare, the effect of staring at a light bulb. Below, color defines edges and allows a simple and elegant *de-gridded* design. For framing fields, the appropriate color should be *light in value* (muting 1 + 1 = 3 effects), and, at the same time, relatively *intense and saturated* (to give a strong visual signal for an active window). Yellow is the only color that satisfies this joint requirement. Thus a two-dimensional display task is handled by two visual dimensions of a single color:



[6] See James D. Foley, Victor L. Wallace, and Peggy Chan, "The Human Factors of Computer Graphics Interaction Techniques," *Computer Graphics and Applications* (November 1984), 13-48; Ben Shneiderman, *Designing the User Interface* (Reading, Massachusetts, 1987); Philip K. Robertson, "Visualizing Color Gamuts: A User Interface for the Effective Use of Perceptual Color Spaces in Data Displays," *Computer Graphics and Applications* (September 1988), 50-64; and also Edward R. Tufte, *Visual Design of the User Interface* (Armonk, New York, 1989). In contrast to the low-resolution and garish color of the computer screen, consider the stamp, with a sometimes delicate use of color (by varying densities of engraving) and fine detail:

WHAT palette of colors should we choose to represent and illuminate information? A grand strategy is to *use colorsfound in nature,* especially those on the lighter side, such as blues, yellows, and grays of sky and shadow. Nature's colors are familiar and coherent, possessing a widely accepted harmony to the human eye — and their source has a certain definitive authority. A palette of nature's colors helps suppress produc-

Gretchen Garner, *A Grove of Birches,* photographs, 1988.

tion of garish and content-empty colorjunk. Local emphasis for data is then given by means of spot highlights of strong color woven through the serene background. Eduard Imhof develops this theme, with his characteristic mix of cartographic science and art:

> *Third rule:* Large area background or base-colors should do their work most quietly, allowing the smaller, bright areas to stand out most vividly, if the former are muted, grayish or neutral. For this very good reason, *gray* is regarded in painting to be one of the prettiest, most important and most versatile of colors. Strongly muted colors, mixed with gray, provide the best background for the colored theme. This philosophy applies equally to map design.
>
> *Fourth rule:* If a picture is composed of two or more large, enclosed areas in different colors, then the picture falls apart. Unity will be maintained, however, if the colors of one area are repeatedly intermingled in the other, if the colors are interwoven carpet-fashion throughout the other. All colors of the main theme should be scattered like islands in the background color. The complex nature of the earth's surface leads to enclosed colored areas, all over maps. They are the islands in the sea, the lakes on continents, they are lowlands, highlands, etc., which often also appear in thematic maps, and provide a desirable amount of disaggregation, interpretation and reiteration within the image.[7]

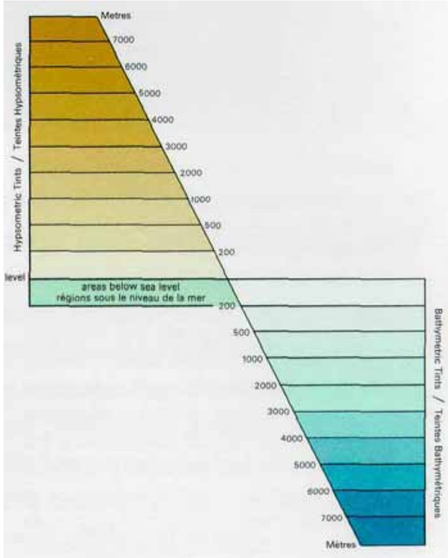
[7] Eduard Imhof, *Cartographic Relief Presentation* (Berlin, 1982), edited and translated by H.J. Steward from Imhof's *Kartographische Geländedarstellung* (Berlin, 1965), p. 72. Here what should be strictly cartographic and information design arguments are pushed too far toward a general theory of aesthetics. Mondrian, Malevich, and many others routinely violate the fourth rule; the problem is with the rule not Mondrian.

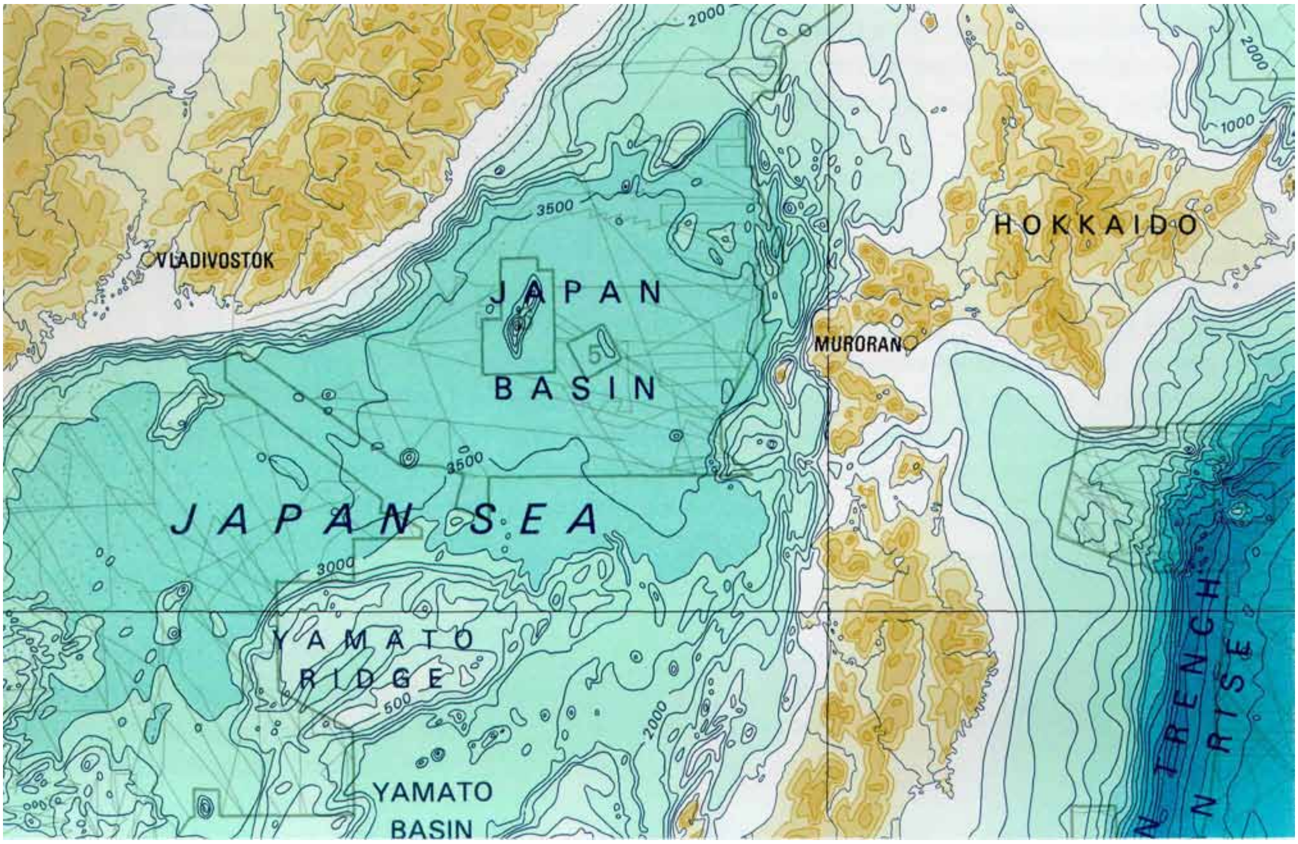
Of course color brings to information more than just codes naming visual nouns — color is a natural quantifier, with a perceptually continuous (in value and saturation) span of incredible fineness of distinction, at a precision comparable to most measurement. For data then as for art: "And what tremendous possibilities for the variation of meaning are offered by the combination of colors... What variations from the smallest shading to the glowing symphony of color. What perspectives in the dimension of meaning!" wrote Paul Klee.[8] In practice everything is not this wonderful, given the frequently uneasy translations from number to corresponding color and thence to human readings and interpretations.

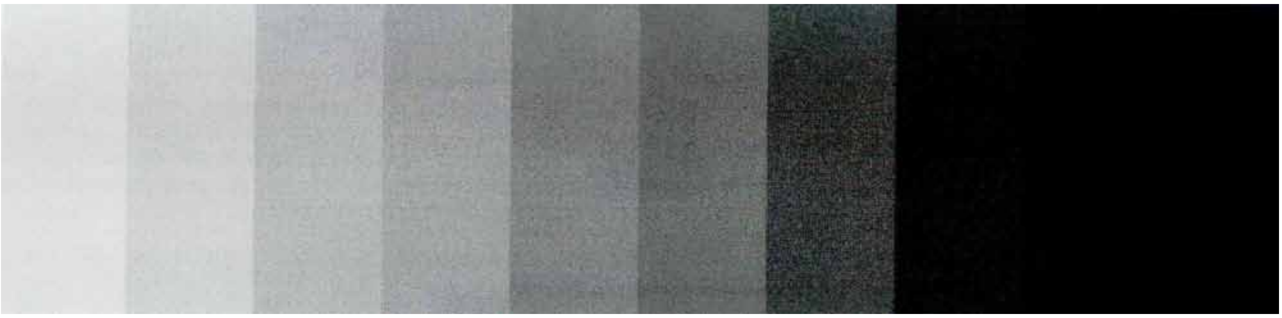
The General Bathymetric Chart of the Oceans records ocean depth (bathymetric tints) and land height (hypsometric tints) in 21 steps - with "the deeper or higher, the darker" serving as the visual metaphor for coloring. Shown are the great ocean trenches of the western Pacific and Japan Sea. Numbered contours outline color fields, improving accuracy of reading. Nearly transparent gray tracks, on a visual plane apart from the bathymetric tints, trace paths of sounding lines (outside those areas of extremely detailed surveys, such as ports and along coast lines). Every color mark on this map signals four variables: latitude, longitude, sea or land, and depth or altitude measured in meters.

[8] Paul Klee, *On Modern Art* (London, 1948), translated by Paul Findlay from *Über die moderne Kunst* (Bern, 1945), pp. 39-41.

General Bathymetric Chan of the Oceans, International Hydrographic Organization (Ottawa, Canada, 5th edition, 1984), 5.06.



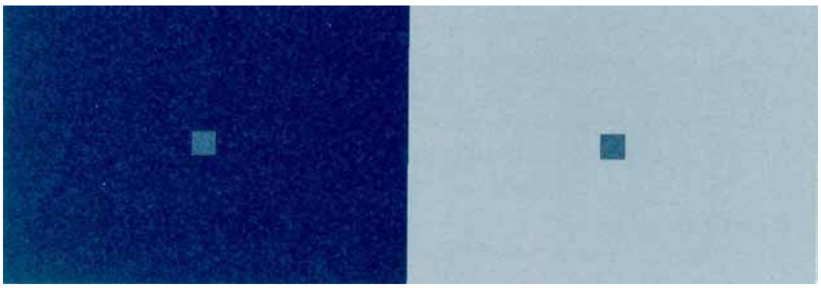


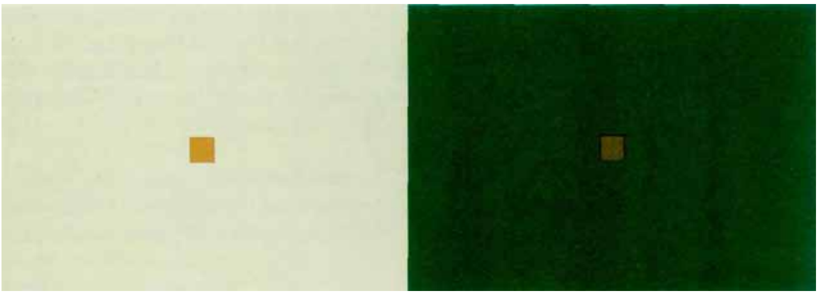


In the ocean map, quantities are shown by a *value* scale, progressing from light to dark blue. Although easy to learn and remember, value scales may be vulnerable to the inaccuracies of reading provoked by disturbing contextual effects, shown above, of edge fluting and simultaneous contrast. A widely-used alternative is a scale of rainbow colors, replacing the clear visual sequence of light to dark with the disorderly red, orange, yellow, green, blue, indigo, and violet — an encoding that now and then reduces perplexed viewers to mumbling color names and the numbers they represent, perversely contrary to Paul Valery's axiom, "To see is to forget the name of the thing one sees." Despite our experiences with the spectrum in science textbooks and rainbows, the mind's eye does not readily give an order to ROYGBIV.[9] In the face of this rainbow encipherment, viewers must turn to other cues (contour, edge, labels) in order to see and interpret data.

[9] Controlled variations in hue, however, help extend value scales, increasing fineness of differentiation and yet still giving viewers a sense of natural visual sequence.

ANY color coding of quantity (whether based on variations in hue, value, or saturation) is potentially sensitive to interactive contextual effects. These perceived color shifts, while an infrequent threat to accuracy of reading in day-to-day information design, are surprising and vivid — suggesting that color differences should not be relied upon as the sole method for sending a message amidst a mosaic of complex and variable data. Here the same color (in the central squares) looks quite different when placed in slightly different circumstances. The small squares are shifted so as to match the opposite surround — a fine





visual touch. Perhaps even more stunning are arrangements of color fields that make two different colors look alike. Albers describes this as a *subtraction* of color: "Repeated ... experiments with adjacent colors will show that any ground subtracts its own hue from colors which it carries and therefore influences."[10] How different the colors of the small squares above look against a uniform white field:

Can these interactions of color *benefit* information displays? Not often, but, in this conventional road map, the perceived visual palette used for labels is extended, without the expense of printing an additional flat color. The thin red line (smaller roads) changes to a deeper red when flanked by parallel blue stripes in the code for larger roads.

Color itself is subtle and exacting. And, furthermore, the process of translating perceived color marks on paper into quantitative data residing in the viewer's mind is beset by uncertainties and complexities.[11] These translations are nonlinear (thus gamma curves), often noisy and idiosyncratic,)" with plenty of differences in perception found among viewers (including several percent who are color-deficient).[12,13]

MULTIPLE signals will help escape from the swamp of perceptual shifts and other ambiguities in reading. Redundant and partially overlapping methods of data representation can yield a sturdy design, responding in one way or another to potential visual complications — with, however, a resulting danger of fussy, cluttered, insecure, committee-style design. A crystalline, lucid redundancy will do.

[10] Josef Albers, *Interaction of Color* (New Haven, 1963), p. 28. In reading these color comparisons, Albers suggests "For a proper comparison, we must see them simultaneously, not alternatingly. The latter way, a repeated looking forth and back, produces changing and disturbing after-images which make a comparison under equal conditions impossible. For a simultaneous comparison, therefore, we must focus at a *center* between the 2 rectangles, and for a sufficient length of time." *(Interaction of Color: Commentary,* p. 16, italics added.) Students of printing may wish to note that reproduction of the various examples here required 23 separate flat colors for this signature.

[11] See Günter Wyszecki and W. S. Stiles, *Color Science: Concepts and Methods, Quantitative Data and Formulae* (New York, 2nd edition, 1982); and, a book better than its title, Deane B. Judd and Günter Wyszecki, *Color in Business, Science and Industry* (New York, 3rd edition, 1975).

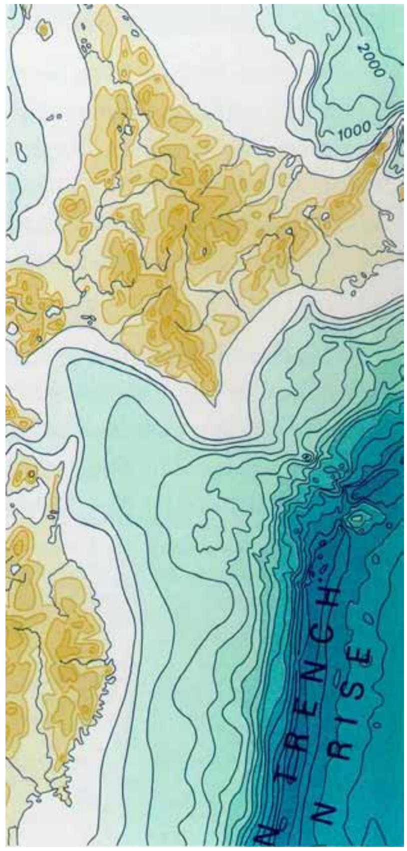
[12] Because of color-deficient vision, it is best to avoid making crucial data distinctions depend on the difference between red and green. See Leo M. Hurvich, *Color Vision* (Sunderland, Massachusetts, 1981).

[13] Also, the specific details of linking color to number must be decided in relation to the information itself, taking into account the frequency distribution of the data, what aspects of the data are to come forward, and the delineation of important cutpoints. For a good analysis of these issues, see Eduard Imhof, *Cartographic Relief Presentation* (Berlin, 1982), translated by H. J. Steward from Imhof's *Kartographische Geländedarstellung* (Berlin, !965), pp. 3!2-324.

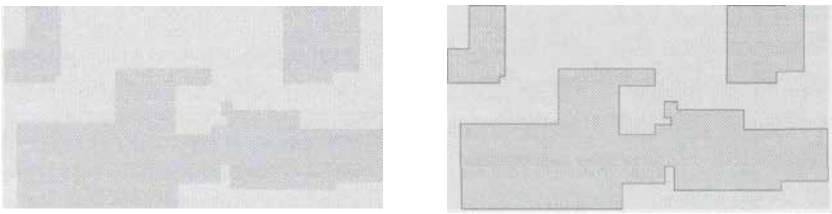
Transparent and effective deployment of redundant signals requires, first, the *need* — an ambiguity or confusion in seeing a data display that can in fact be diminished by multiplicity — and, second, the *appropriate choice of design technique* (from among all the various methods of signal reinforcement) that will work to minimize the ambiguity of reading.[14] Disregard of these conspicuous distinctions will propagate a gratuitous multiplicity. Several examples, illustrating mutual interplay of color and contour, give our verbal pronouncements a visual reality.

[14] Wendell R. Garner, "Information Integration and Form of Encoding," in Arthur W. Melton and Edwin Martin, eds., *Coding Processes in Human Memory* (Washington, D.C., 1972), 261-281.

The ocean map exemplifies a sensitive multiplicity: the color fields which encode depth are in turn delineated by contours labeled with depth measurements. These lines eliminate edge fluting and make each field a more coherent whole, minimizing within-field visual variation and maximizing between-field differences. Edge lines allow very fine value distinctions, increasing scale precision. Between fields, only the *presence* of an edge is needed, a *thin* line of a color not too distant in



General Bathymetric Chart of the Oceans, International Hydrographic Organization (Ottawa, Canada, 5th edition, 1984), 5.06.



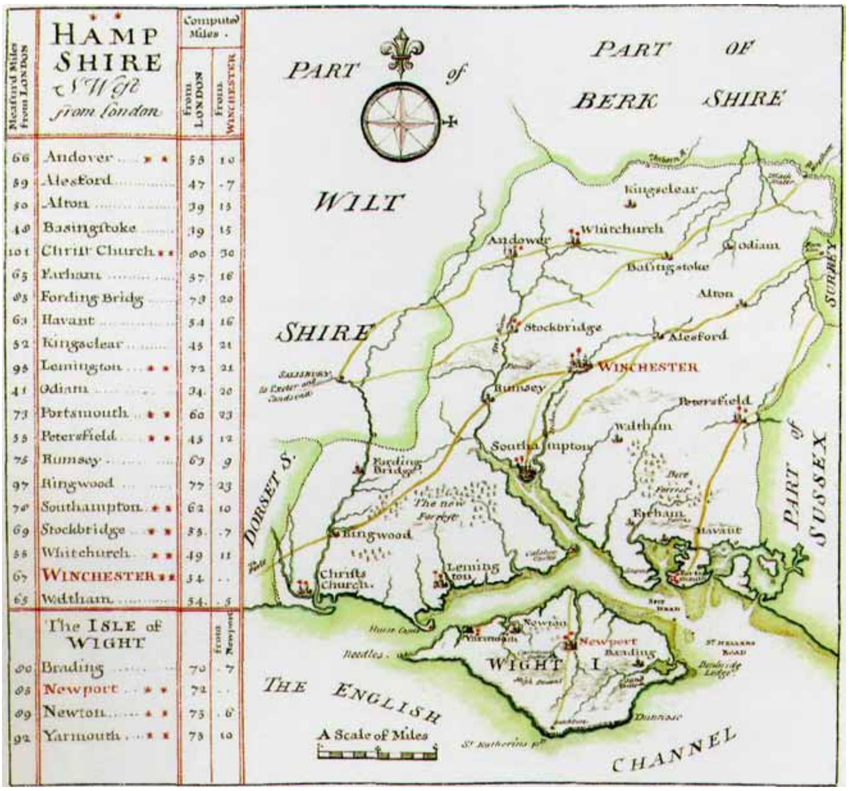
Planviews drawn by Pamela Pfeffer, student project, Studies in Graphic Design, Yale University, 1988.

value from the scale itself (at left, 3% and 7% screen tints for ground and for building; at right, exactly the same tints with edges). Note the dramatic effect of the contour here, visually shifting color within the outlined form, sharply distinguishing the building from the surrounding ground. This technique of cartography and graphic design is confirmed by theories of vision, which point out that human cognitive processing gives considerable and often decisive weight to contour information.[15]

[15] David Marr, *Vision* (San Francisco, 1985), pp. 215-233.

In this map, the color merely delineates what is already obvious. Laid down in broad unrefined bands, the strong colors induce a loss of focus of detail on the entire map, making it something to be read only at poster distance. So much visual excitement, so little data, merely to outline a shape

William Henry Toms after Thomas Badeslade, *Chorographia Britannica or, A Set of Maps of all the Counties in England and Wales* . . . (London, 1742), plate 18.



Thomas Badeslade, *A Compleat sett of Mapps ofEngland and Wales in General, and ofeach County in particular . . .* (1724), pen and ink, and watercolor on vellum, leaf 35 (recto).

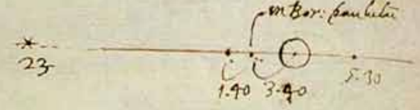
already familiar to most viewers of the map. Boundary lines should be drawn so as to show clearly what falls on which side, essential details lost here in color cross-hatching. The color misses the point.

The map at left is an unsuccessful imitation of the beautiful original above, translucently aglow with delicate light. Outer areas are given less emphasis, with color gently defining roads, boundaries, and cities. City symbols are marked by red stars indicating how many members each place sent to Parliament in 1724. At any rate, a clear statement about geography, rather than a statement about color.

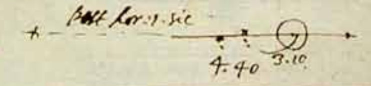
"ALL things are always on the move simultaneously," as Winston Churchill once described military strategy. So it is also for design and color; even simple visual effects can involve a simultaneous complexity of design issues. For this Japanese textile pattern, white dots produce a slight *contextual color shift* nearby, as in the Albers examples of color interactions. Surrounding the dots and the narrow band of shifted color are *cognitive contours*. And these contours in turn produce a *homogeneous edged field,* a result we have seen both in the ocean map and in the gray tints of the building planviews.

1612

Xbr. D. 16. H. 1.30 ant ☉ ortu. i D. 15. h. 18 [illegible]



post hor. 1. sic



Xemb. D. 17. ho. 0.20 post ortu ♃ qui fuit Hor. 3.50 ante ☉ ortu i D. 16 Hor. 15.47 [illegible]

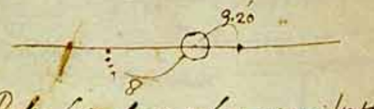
Occidentales fuerut 2 coniuncti [illegible]: et tamen steterunt in σ. adeo ut uix h. [illegible] ante ☉ ortu aliqd di separationis [illegible] poterat animaduerti. [illegible] ita, et occidentalior in bor. uidebat paululu attolli: et tuc distabat a ♃ 8. semid.os quae obseruatio mirae immodu confert ad emendatione tabularum

D. 18. ho. 0.20 post ortu ♃ qui fuit ho 4.0 ante ☉ ortu. i D. 17. ho. 15.37 [illegible]

Post 2 horas cum esset ♃ uicinior [illegible] amplius separati ipsaru altera in ♃ umbra incidens no amplius apparebat reliqua u° distabat a ♃. 3.20.

D. 19. ho. 0.30 ante ☉ ortu i D. 18. hor:

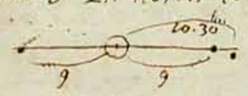
D. 20. h. 1. post ortu ♃ i D. 19. ho.



Reliq latitabant sub ♃ et occidentalis quoq ad σ properauit: [illegible] [illegible] ut reliquas separationes uideremus [illegible] hor. 4. no uidimus, postea somno [illegible] atq deceptis diutius obseruare no [illegible]

1612

Xmbr. D. 27. Hor. 15.46 a m: du ♀ oriret



post ☉ ortu 0.30. 2 occidentales erat prope coniuncte distabant n. 0.20 in longitudine sed occidentalior tanta habuit latitudine ut appareret [illegible] quod in ipsa copula altera uix et ne uix quidem tangeret. et eade hora 4. ex occidente stella aderat et orientalis remotior facta fuit; erat q talis configuratio; et tabule ad ungue responderent.

D. 29. Hor. 19.0 a mer:

Dubia ob nubes

1613.

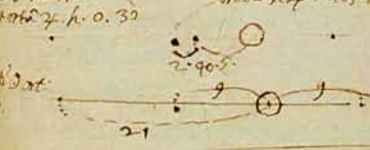
Jan: D. 2. hor. 12. a mer.

30 seu ho. 2.30 ante ☉ ortu sequetis diei

D. 3. ho. 12. a mer.

in austru satis deflectebat

ortu ♃ h. 0.30



D. 5. Ho. ~~6.34~~ 7.12 ab occ. a mer. u° ho. 11.38

Exactiss. Obser.

6.4

ho: 6.18