"*Graphesis* is a sophisticated critique of some of the foundational assumptions of HCI (human-computer interaction), interaction design, and information visualization. Drucker makes a compelling case for the value of humanistic inquiry into subjects that have traditionally belonged solely to computer experts and social scientists."

Maria Engberg, Assistant Professor, Media Technology, Malmö University
&
Jay David Bolter, Professor, Digital Media, Georgia Institute of Technology

"*Graphesis* is a significant contribution to the field, every bit as important as Drucker's *The Visible Word*. Indeed, the world has changed, and information design has shifted significantly with it. In this text, Drucker should be applauded for taking a broad view of her subject, tackling little studied imagery as well as visual systems of thinking."

Elizabeth Guffey, Professor of Art and Design History at Purchase College, State University of New York

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Drucker + Graphesis Visual Forms of Knowledge Production

Harvard

Johanna Drucker

Graphesis
Visual Forms of Knowledge Production

Image, Interpretation, and Interface

Even though our relation to experience is often (and increasingly) mediated by visual formats and images, the bias against visual forms of knowledge production is longstanding in our culture.[3] Logocentric and numero-centric attitudes prevail. Vision has served knowledge in many ways across the sciences, arts, and humanities in theoretical and

applied domains. Attention to style, iconography, and other formal properties is well developed in the fine arts, where concerns with connoisseurship and the social function of images drive the field. We also know that pictorial images reveal much about the history of visual culture and knowledge and that familiar art historical theories and methods are used for their analysis. Despite its sophisticated knowledge of visual production, art history has not focused on visual epistemology as a primary concern. For a brief period in the formative stages of modernism, particularly in the early decades of the twentieth century, concerns with formal systems of visual expression brought major artists such as Wassily Kandinsky and Walter Crane into discussion of graphical knowledge production.

The field of visual epistemology draws on an alternative history of images produced primarily to serve as expressions of knowledge. For the study of graphesis, attention to fine art images will be largely left aside in favor of attending to the vast array of visual work produced for the purposes of interpretation or analysis in other fields. For different reasons, but by the same logic, graphic design works will also be left out of this discussion, except for the subset that overlap with information visualization, such as the elaborate work of Otto Neurath or studies by Anton Stankowski. Since we inhabit a world permeated by digital technology, we will address the urgency of finding critical languages for the graphics that predominate in the networked environment: information graphics, interface, and other schematic formats, specifically in relation to humanistic problems of interpretation. To do this we can draw on the rich history of graphical forms of knowledge production that are the legacy of manuscript and print artifacts as well as digital media works in the arts and applied realms.

The language of graphics

Many attempts have been made to create an explicit, stable, universal, and rule-bound language of graphics. Such a language actually has two aspects: a highly formal set of visual elements with rules for their use and a verbal description of this system and the ways it works.

The most complete graphic language systems appear in the twentieth century, as adjuncts to design curricula and professional training. They played a crucial part in the "research" agendas that were part of visual art's claim to cultural authority in the modern era. Work at the Bauhaus, as well as in the technical academies and design schools founded in the 1920s and 1930s, such as Vkhutemas in Moscow, fostered a brief but generative dialogue between visual practices of design and those of fine art. Graphic design became a distinct profession in this period, while the fine arts absorbed the formal lessons of modern abstraction into aesthetic concerns. Visual epistemology may have been integral to engineering, architecture, industrial design, textiles, cartography, scientific illustration, and statistical analysis, but it failed to become a separate field among academic disciplines. Information visualization, graphics in the service of quantitative methods, remained a subset of business, economics, statistics, and other fields where the use of charts, graphs, and diagrams proliferated. Fine artists had only intermittent interest in these matters until the recent wave of data art and visualization work became a conspicuous trend in digital practices.[4]

Though ignored by fine arts for most of its history, the systematic production of graphic knowledge has a very long tradition. For instance, we could track into the records of antiquity and examine treatises on geometry that have left their trace in the scant but precious remains of written documents

from Egypt and the ancient Near East. We can argue that visual knowledge can be considered codified as soon as the graphic forms of triangles, squares, circles, and arcs are described in drawings and texts.[5] These treatises are not drawing or design manuals, but they are graphical expressions of mathematical, logical, knowledge in a systematic visual and verbal form. By contrast to such mathematical treatises, the works that comprise the "language" of graphic communication centuries later are more rhetorical than logical, and their features can be described in terms of visual principles that relate to sight, perception, cognition, cultural conventions, and norms. All of these investigations of visual forms as a systematic expression of knowledge contribute to the search for a "language" of graphics.

The links between knowledge and visuality not only have historic roots, they have historical and cultural dimensions. Our ideas about images and even vision are different from those common in earlier epistemic moments. We no longer believe in the Roman Lucretius's imaginative idea that vision is produced when films float from the surface of objects into our eyes—any more than we believe a picture goes from our eye to our head like a letter being delivered by a postman or a fax being transferred across a wire.[6] The representational approach to vision is passé. We now know that the affordances of our senses and the capacities of cognition together construct the impression of a visual world. The world we see is a world made by our cognitive ability. Indigenous peoples map their territory in vastly different conventions than western cultures, and with a different orientation to the globe itself. The point? Images have a history, but so do concepts of vision and these are embedded in the attitudes of their times and cultures as assumptions guiding the production and use of images for scientific or humanistic knowledge.

The theoretical, methodological foundation for graphesis as the visual approach to knowledge production has to be cobbled together from a variety of contributing intellectual traditions, each with its own disciplinary roots. These approaches to the systematic understanding of visual epistemology will form the core of my approach:

- Knowledge and/as vision: the ways visual ordering and classification serve intellectual work, particularly with respect to issues of interpretation;
- Languages of form: the formal systems in which visual forms have been classified and characterized;
- Dynamics of form/universal principles of design: the extension of the "languages" metaphor to universal and dynamic systems;
- Gestalt principles and tendencies: the principles of perception that locate visual knowledge in psychology and human experience;
- Basic variables: the contributions of the semiotics of graphics;
- Understanding graphics and editing: techniques of framing and reading;
- Processing images: basic issues in computational vision; and finally,
- Typology of graphic forms presents ways of classifying graphic images in current use for humanistic projects.

These topics do not offer a history of information visualizations per se, but they do provide a historical and critical foundation for understanding formal graphic languages in information visualizations and graphical user interface as adopted to the humanistic domains from a vast array of sources.

Knowledge and/as vision

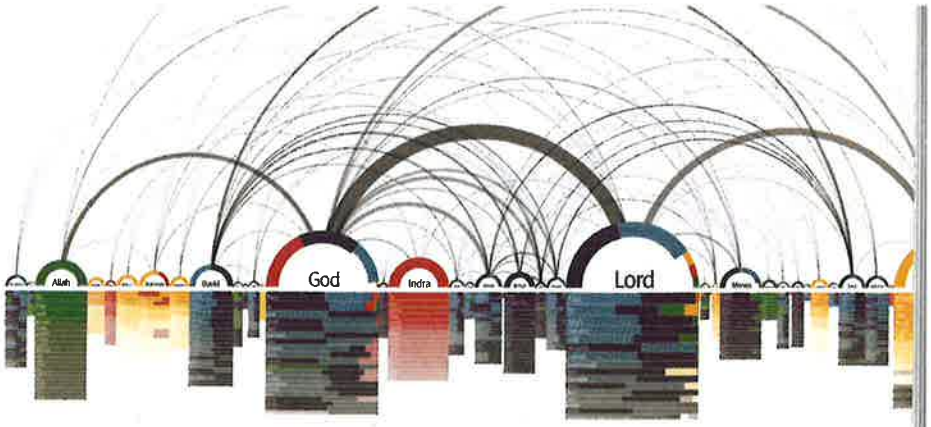
Vision was given highest priority in the hierarchy of senses among the Ancients, and then, from the late Middle Ages through the Enlightenment, human vision was augmented through the use of technical instruments. Perhaps these factors intensified the belief that the workings of the natural world might be made apparent to and through the eye, and that careful observation was the key to unlocking the workings of the universe.[7] What could be seen could be known, and knowledge and sight had a reliable connection even if visual means of representing that knowledge were taken for granted rather than studied in their own right. Observation and recording were used since ancient times to diagram the movements of the heavenly bodies, to make an inventory of botanical specimens in manuscript production before the age of print, or to chart a course navigating partially known or unknown territories. Different technologies and media play their role in knowledge production as surely as do changes in optical instruments and observational techniques. Study of the specificity of graphic media has its own critical tradition.

For example, the art historian William Ivins stressed the full impact of copperplate engravings, and their ability to produce "exactly repeatable statements," on the fields of natural history as well as fine art in the fifteenth and sixteenth centuries. Later, lithographic and photographic capacities added naturalistic accuracy to visual images in widespread circulation.[8] Mechanistic reproduction expanded and various mass media used new techniques for the creation of visual culture.[9] Expectations about images changed and even the concept of what constitutes a likeness alters over time. We come to believe that photographs are an unmediated image,

what Roland Barthes called an "image without a code," and continue this belief as digital methods of scanning, altering, and creating have developed.[10] But of course, all images are encoded by their technologies of production and embody the qualities of the media in which they exist. These qualities are part of an image's information. Just think how quickly image quality in digital output or even screen resolution becomes identified with a particular moment in history. Woodblocks, daguerrotypes, silver nitrate black and white film, Technicolor, or early digital animation signify by their production features as well as their contents. The emerging field of media archaeology puts attention to the specificity of production means at the center of its methods, reading the matter of media as the foundation on which they configure meaning.[11]

When the late sixteenth century Dutch engraver, Johannes Stradanus, set out to create a suite of prints showing the inventions that had produced modern life, *Nova Reperta*, he subscribed to the belief that every aspect of human knowledge could be communicated visually. But times change, and paradigms shift. We are keenly aware that the breadth and depth of contemporary knowledge exceeds the capacity of visual presentation. We no longer believe that everything that can be known can be seen any more than we believe in the "truth" of visual images. Though we often use visual means to make images of invisible things, much of contemporary life simply can't be shown. The workings of power, the force of ideology, the transmission of values, and other abstract ideas have no specific visual form, even if they work through a material social world.

Johannes Stradanus, illustration of copperplate production, from his *Nova Reperta* (1638).

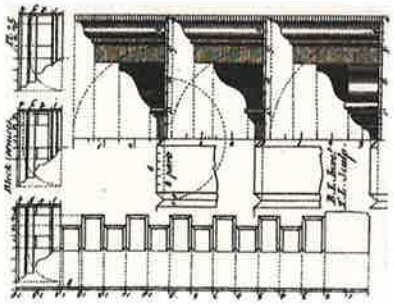


Speed, scale, complexity, and the infrastructure in place and at work in systems of communications, production, distribution, much scientific discovery, and humanistic thought simply cannot be made apparent in visual images. But an endless stream of visualizations continues to turn complex phenomena into images, reifying abstractions, turning them into objects to be seen.

At the same time, in spite of its widespread use, visual representation remains suspect as a form of knowledge. The mathematician René Thom once stated unequivocally that knowledge could only be communicated using one of two modes of expression: mathematical notation and written language.[12] He deliberately excluded graphical means as unreliable. Visual codes are notoriously unstable, too imprecise to communicate knowledge with certainty. And humanistic visual knowledge was bracketed out of his account with particularly good reason: its methods threaten the very foundations of epistemological stability and mathematical certainty that align with empirical tenets.

Thom had good reason to be suspicious of humanistic knowledge, with its emphasis on interpretative rather than quantitative methods. And he was also correct in his implied assessment that visual images have no single identifiable code, and thus did not meet his standards for scientific notation. Language can be rendered in characters, these can be

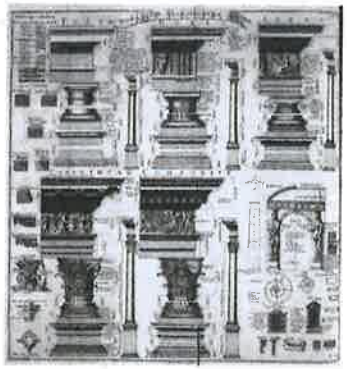
Philipp Steinweber and Andreas Koller, convergent and divergent designations of god in Buddhist, Hindu, Islamic, and Christian texts.



Batty and Thomas Langley, *The Builder's Jewel, or the Youth's Instructor, and the Workman's Remembrancer,* plate 75 (1741).

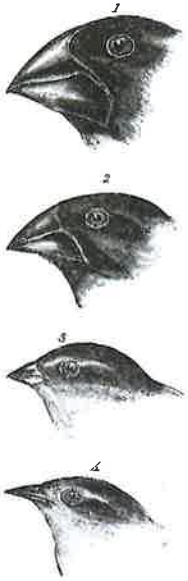
communicated to the computer through keystrokes that link to binary codes in an explicit system. Textual meaning may be ambiguous, but the remediation of alphabetic code into digital form is not. Likewise, numbers represent quantities in an unambiguous way that is stable and repeatable. But the marks and signs that make up an image are neither semantically consistent—that is, they don't represent meaning or value in a dependable way—nor are they graphically consistent, unless they are produced with mechanical means. Even at a higher level of organization, above the basic units, signs, or elements of the system, visual images are not constructed by a given set of rules. Unlike language, which has a grammar, or mathematics, which operates on explicit protocols, visual images are not governed by principles in which a finite set of components is combined in accord with stable, fixed, and finite rules.

But Thom overlooked the ways graphical representation has encoded and communicated knowledge for centuries. Systematic uses of visual images have created standards and consensus across a wide variety of disciplines that depend on visual observation and analysis.[13] Architecture provides a particularly useful example of this since analogies with language as a formal system were central to description and analysis of building styles from late antiquity. The classic text of Vitruvius, composed late in the first century, contained a typology of architectural forms that became the basis of western Renaissance writings on the topic.[14] Sebastiano Serlio's *Regole generali d'architettura,* first published in 1537, for example, presented Vitruvius's classical orders as a set of rules governing visual organization.[15] Like Andrea Palladio's 1570 *I quattro libri dell'architettura,* Serlio's text codified Vitruvian principles and became the reference for all later description of the elements of classical architectural design.[16] Not only did these works present a set of terms and references, but, more significantly for our discussion, they put firmly in place the concept that a visual system might be structured like a language. Style, motif, texture, color, and materials all aligned with semantic elements while relations, composition, sequence, narrative were considered parts of a syntactic function. This concept could, and would, be adopted in many other fields. Its roots in classical form appealed to the Renaissance sensibility, its apparent rational ordering principles to Enlightenment thought, and the articulation of universal formal principles to modernists trying to find a scientific basis for visual work.



Ephraim Chambers, the classical orders, *Cyclopaedia, or Universal Dictionary* (1728).

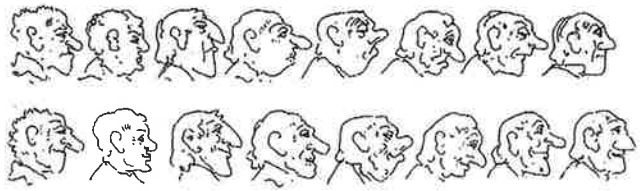
Architectural styles could be described as a language by using language, but they also relied on the use of graphic techniques that supported visual comparison and inscribed features of style, proportion, and decoration. These were imitated over and over, and became so conventional that the initial innovation in graphic presentation came to be taken for granted. This is true in other fields as well where visual presentation is essential for the purpose of communication or analysis. Herbalists, astronomers, navigators, and medical practitioners depended on visual information even if a theory of visual epistemology was not made explicit until much later. A handful of major precedents ap-



Darwin's finches, a study in beak adaptations, *Voyage of the Beagle* (1845).

pear earlier, but the gap between the use of visual images to communicate knowledge and the development of the concept of a "language of graphics" was only closed in the twentieth century—when formalized rules of visual communication were articulated in very deliberate terms.

Like architecture, the study of physiognomy depended on visual forms, but it is an entirely interpretative system. Giambattista Della Porta's analysis of character, *De Humana physiognomonia*, published in 1586, connects visual experience to assessment.[17] Through examination and representation of facial features, skull proportions, expressions, and postures, the work classifies through depiction. Porta created a systematic analysis that depended on making links between visual features and value judgments about character. Visual images and physiognomy remained bound to each for centuries, even across changes of media. Johann Kaspar Lavater's later work on physiognomy, published between 1775–1778, got much of its long-standing rhetorical force from its engraved images while the famous French forensic investigator, Alphonse Bertillon, used photographs of hundreds of criminals in order to affirm his convictions about degenerate character types and their ability to be detected visually.[18] Physiognomy exemplifies

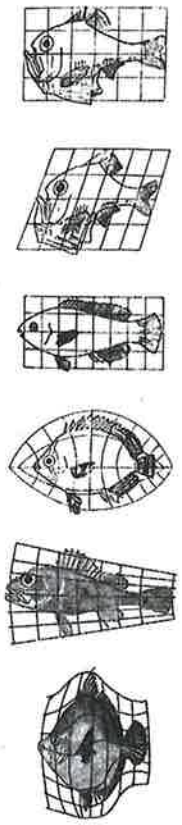


Rodolphe Toepffer's graphic inventory of profiles, *Essay zur Physiognomie* (1845).

a specific method of producing interpretative knowledge and social consensus in and through graphic representations. Caricaturists made good use of these methods, playing on the ways graphic codes established categories and provoked spe-

cific associations in viewers. In both cases, architecture and physiognomy, the information embodied in physical form becomes codified through graphic representation.

Graphic methods are crucial to scientific work, either for recording observation, expressing results, testing hypotheses, or formulating projects within the terms of epistemological debate or at its edges. Etienne Marey's 1878 *La Méthode graphique* was premised on the recognition that certain scientific investigations required graphic means for the precision they offered in circumstances where language failed.[19] His photographic studies of motion introduced techniques of analysis that were specifically visual, breaking the continuum of movement into discrete images for study. But the analysis of graphics as a system, one that could be governed by predictable rules, explicitly articulated, arose within the visual arts. Specifically, these systems of rules arose in the arena of applied drawing useful for industry and engineering. In these realms drawing was more linked to surface organization of elements that provided plans and patterns for production than to the creation of pictorial illusion.



D'Arcy Thompson, models of formal mutation from *On Growth and Form* (1917).

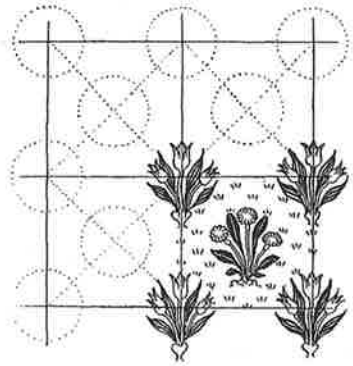
Drawing manuals and treatises on painting created by fine artists were too heavily linked to the study of classical statues, systems of proportion and harmony, and perspectival rendering of space and atmospheric effects, to develop analysis of purely formal elements of graphic production and composition.[20] They focused on pictorial principles, approaches to shade, rendering, or inspiration—as in Leonardo's famous suggestion to use a smudge or stain or blot of dirt as a hallucinatory point of departure for drawing.[21] The very idea of graphic-ness, attention to the surface of a visual plane on which compositional elements interacted—not merely as representations of other things, but as elements in themselves—required a conceptual leap. Just as we associate

the self-referential attention to the picture plane with a phase of visual modernism, so we can note that, for all the evidence that cave painters, Egyptian muralists, Native American weavers, medieval illuminators, or Islamic tile-makers understood how to create dynamic compositions using the elements of graphic design on a plane surface, the systematic articulation of a graphic method only started to appear in the nineteenth century. The full intellectual import of this oversight can be grasped if we were to imagine, by analogy, that no explicit grammars had been written until the same period. The rules that govern language structures, combination, and use have been in existence for thousands of years, as have the rules of mathematics and music. This makes the relatively recent, and still partial, articulation of principles of graphics that much more astounding.

Languages of form

In 1856, a milestone work brought the metaphor of visual language into focus. *The Grammar of Ornament*, produced by Owen Jones, was a massive, monumental sourcebook, a comprehensive encyclopedia of decorative motifs taken from every cultural and historical period known to Victorian Britain.[22] It embodies the imperial impulse of its time and place by the sheer comprehensive exhaustion of range and reach. Persian, Indian, Chinese, African, Indonesian, Polynesian, and other indigenous and exotic designs are among the scores of styles presented alongside those

Owen Jones, *The Grammar of Ornament* (1856).



from antique, medieval, and Renaissance sources in Western culture. As graphic art, the stunning chromolithographed pages exhibit a rational and systematic approach to the presentation of ornament in both semantic and syntactic modes. The semantic modules are iconographic elements, figures, isolated units of organic or geometric design. The syntactic elements are strips or fields of motifs exhibiting continuous, interwoven, repeated units and patterns combined in integrated compositions as well as the overarching compositional structure of each page in relation to the whole system of the book. For Jones, grammar is not just a concept to be invoked or waved at, but a structuring principle to be engaged in the production of his own project even if he did not say these things explicitly. Jones did not divide his "grammar" into semantic and syntactic operations, but he offered examples that can be described in these terms.

Jones produced the most ambitious pattern book in the history of Western art, and he made skilled use of graphical means and principles, but his purpose was not to spell out the rules of graphic language. Other individuals would do this, equally concerned with the relations between industrial production (Jones was providing the textile, ceramic, and decorative paper manufacturers with a goldmine of inspiration) and visual techniques. New training demands arose as industrial, applied arts were put in the service of the production of artifacts, wall-coverings, books, posters, textiles, and other mass produced objects. This created a need for systematic education in creation of pattern and form, shape and design, not pictorial illusion. In such a cultural context, graphic arts had a role to play at a different scale than in the past eras

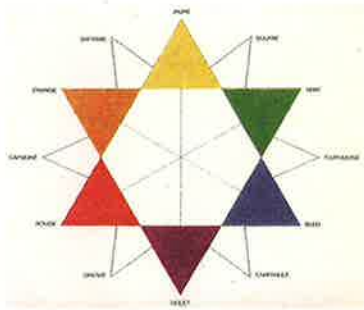
Walter Crane, *Line and Form* (1900).

David Pierre Humbert de Superville, synoptic table from *Signes Inconditionnels de l'art* (1827).

of artisans and illuminators. Objects of manufacture had to be patterned from flat sheets of wood, metal, tin, and cloth, just as surely as decorative motifs had to be created for automated print production. Thinking in graphic terms served production exigencies tailored to the tolerances of machines, not hands, knowledge that had to be systematized in order to be passed on effectively. The "language of graphics" became a language for and of industry, even as analysis of abstract visual form became one of the distinctive features of late nineteenth century aesthetics and its legacy to twentieth century modernism. The rhetoric of supposedly universal formal principles is historically coincident with the need for an abstract graphical approach to design for industrial production.

But interest in affect and effect, emotional force of communication and predictable impacts, play a part in the investigation of graphic forms as well. Just as these systematizations of visual languages emerged, another intriguing harbinger appeared: Humbert de Superville.[23] His analysis of configurations of line and compositional features as expressions of affective and emotional conditions was presented as a system in his 1827 study of "absolute" qualities of visual art. Superville's *Essay on Non-conditional Signs in Art* isolated features of graphical elements, such as diagonal lines, to argue that their effect was universal. While his work borrows from physiognomic analysis, and from the typologies of Renaissance drawing, the attention to dynamic principles of lines and configurations has kernels of the rigorous formalism that became so prevalent in design manuals a century later. Superville was focused on graphic values he believed were universal, an attitude that would infuse the twentieth century modern arts with theoretical premises. Combined with his primitive attempt at systematicity, this provided a crucial early contribution to methods of graphical knowledge.

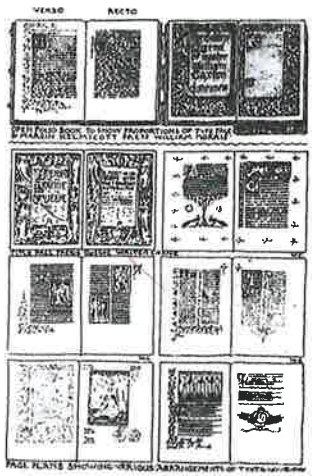
In France, instruction in drawing for industrial purposes became systematized in the late nineteenth century following a proposal put forth by Eugène Guillaume, sculptor and educator, who saw that the old techniques of copying classical statues, studying Renaissance methods of perspective, and/or learning the Beaux Arts approaches to rendering were not going to produce a generalized graphic language suitable to industry.[24] Guillaume understood that it was necessary to cut ties to fine arts in order to produce a practical system based in geometry, not the human body. This put his approach at odds with the history of training in the fine arts. We can think of this as a kind of machine-readable graphic language, long before the advent of digital technology. His emphasis was on knowledge of creating curves that could be stamped or cut by a die, rather than rendered with exquisite precision in charcoal or graphite. Titles invoking a "grammaire" of drawing became conspicuous as foundations for instruction as the nineteenth century came to an end. Design was uncoupled from the task of life drawing, but interestingly, not from the communication of affective experience. Superville's principles of the communicative effect of graphical means found a continuation and echo in Charles Blanc's *La Grammaire des arts plastiques* published in 1870, and the description of affective, emotional, and symbolic features of graphic elements was central to the work of turn of the century theorists, as we shall see in a moment.[25] So even as geometric, linear, abstract forms essential to industrial design became codified in training manuals, theories of the emotional impact of arrangement—the force of diagonals, emotive qualities of color, or other formal features—developed at the same time.



Charles Blanc, illustration from chapter 13, *Grammaire des Arts du dessin* (1867).

Walter Crane, sketches for book layout designs in *Line and Form* (1900).

Right at the end of the nineteenth century, the English illustrator and artist Walter Crane produced two major contributions to graphical analysis: *The Bases of Design* (1902) and *Line and Form* (1900).[26] These two works, though couched in a discursive, descriptive mode, rather than that of a technical manual, are exemplary demonstrations of a methodical approach to a "language" of graphics that proliferated in the twentieth century. Crane had been a student of the widely influential artist and critic, John Ruskin, whose style of careful study, sketching, and observation had formed the basis of his own publications on *The Stones of Venice* (1851-53) and other subjects.[27] Crane's *Line and Form* in 1900 contains a masterful drawing that was a comprehensive inventory of graphic lines and shapes put into a tree-like relation with "parent" forms of square and circle at the base. Crane was a gifted designer as well as a superb illustrator whose approach to composition was dynamic and imaginative, informed by the best work in Western art combined with Asian influences and other diverse sources. Asymmetry, fluidity, movement, and dynamism charged his compositions even when their basic compositional forms had solidity, balance, proportion, and harmony.



[See Window 1, Walter Crane]

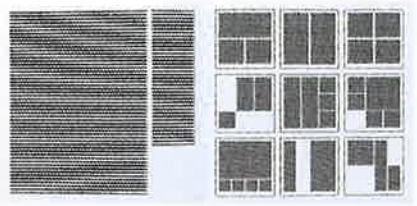
What is remarkable about Crane's inventory is not just its attempt at exhaustive presentation, but the structure in which the artist chose to present this knowledge. The tree's root and branch structure echo morphologies from natural and cultural worlds pressed into the service of a graphical one. As a formal system, Crane's image is fraught with contradictions, since the improbability of a square-edged meander arising from a tap root that

spawns floral branches above and diagonal repetition nearby renders the organizational trope of the image somewhat irrelevant. But as a conceptual system whose goal is to present the language of graphics in a formalized way, it serves remarkably well as a transition between nineteenth century organicism and twentieth century modern analyses of "graphic languages" or grammars. Crane analyzed the attributes of graphical elements, suggesting that weight, tone, value, pattern, and rhythm each contributed to the identifiable character of an artist's signature style—or that of a period, culture, or ethnic group. Materialist in his methods, Crane was also attached to the analysis of the symbolic character in forms, analyzing the impulse toward conquest in ancient Asiatic art and the generative imagery of the Egyptians. Systematic and replete, Crane's work was meant to train the eye and mind at the same time, providing cultural references and analyses as well as formal means for production.

Dynamics of form/universal principles of design

In the late nineteenth century, the idea that design was a skilled profession whose principles were graphic, not pictorial, and whose "language" was built on an analogy with verbal language began to gain traction. New practices emerged from product and pattern design, analysis of ornament and organization. These needed an explicit articulation of principles that could be taught in a technical training course, not just learned on the shop floor.[28] The rapid escalation of interest in graphic languages for their own sake, and on the development of systematic principles can be marked by shifts from purely technical manuals to those concerned with graphic principles. Late nineteenth century typographic manuals, for

instance, contained technical information about composition, typecasting, imposition of pages in complex layouts meant to assist the printer, but no discussion of design principles. These had hardly changed since the days of Joseph Moxon's *Mechanick Exercises*, first published in 1694.[29] Almost no systematic or "meta" discussion of graphic design occurs until the field becomes part of curricula in the 1920s, since the very concept of the profession had to evolve from the murky origins of life on the shop floor and at the draftsman's desk. In the first decades of the twentieth century, writings by Jan Tschichold, Frederic Goudy, Bruce Rogers, and Stanley Morison, though very different in taste and orientation, contributed to a growing trend. Attention to composition as an art, not merely a technique, became fully evident for the first time and a full-fledged metalanguage of graphics takes shape.[30] Tschichold stands out among these figures as the person whose statements of principles in *The New Typography* (1928) and *Asymmetric Typography* (originally published in German in 1935) articulated a graphic method, not just a statement of aesthetic belief.[31]



Jan Tschichold, *Die Neue Typographie* (1928).

In the early twentieth century, visual artists engaged with modern methods became enthralled with visual abstraction as a formal system. To reiterate, this was a unique and short-lived moment in the history of fine art, a rare engagement with graphical forms rather than problems of formal, iconographic, or conceptual matters. The idea that visual art might have a method that produced reliable and repeatable results gave it an air of authority. Not only were artists interested in the exciting visual possibilities of working with either reductive ("abstracted") forms arranged in a dynamic

manner on a picture plane or "purely formal" ("non-representational") elements, but they were also keen to articulate what they believed were "universal" principles of visual form. Wassily Kandinsky and Paul Klee were among the artists giving voice to these ideas, and they formulated some of the earliest complete theoretical texts.[32] They shared a formative experience at the Bauhaus, and were connected with newly created institutions in the young Soviet state that were working along similar lines. Enthusiasm for the role of the artist in industrial design, synthesis of spiritual principles and formal ones in concepts of universal properties of form (resonance, vibrations, tone as well as compositional effects), and an interest in systematizing approaches to teaching graphic form for applied research and development were all elements of their approach.[33]

This interest in formal methods was part of a broader cultural sensibility in which attempts at formalizing the representation of thought in logic, linguistics, structuralist analyses across cultural domains, and social sciences became prevalent, as evident in the writings of George Boole and Augustus de Morgan taken up by members of the Vienna Circle, such as Gottlob Frege, Rudolf Carnap, and young Ludwig Wittgenstein working at the intersections of logic and language. A direct line connects Boole's 1854 publication *Laws of Thought* to George Spencer-Brown's *Laws of Form*, published a little more than a century later, in 1969. The phrase, "languages of form," adopts these formalisms as the basis of foundation courses in graphic communication. Its roots are in the Bauhaus curriculum developed by these artist-designers keen to produce a systematic approach to visual literacy. Like his earlier 1910 essay, *Concerning the Spiritual in Art*, Kandinsky's 1926 publication, *Point and Line to Plane*, clearly shows the influence of late nineteenth century Symbolist

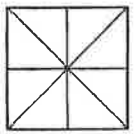


Fig. 96
Silent lyric
of the four elementary lines—
expression of rigidity.

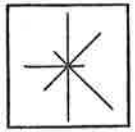


Fig. 96
Dramatization
of the same elements—
complex pulsating expression.

Use of the eccentric:

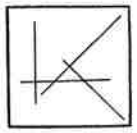


Fig. 97
Diagonals centered.
Horizontal-vertical eccentric.
Diagonals in the greatest tension.
Balanced tensions of the
horizontal and vertical.

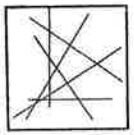


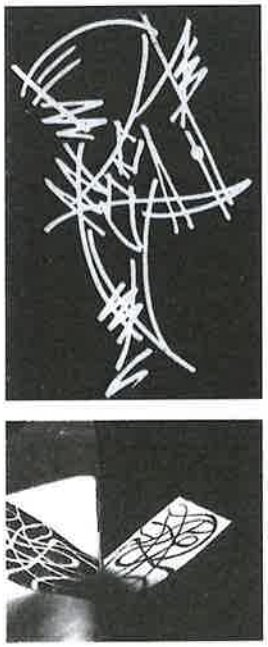
Fig. 99
Everything eccentric.
Diagonals strengthened
through their repetition.
Restraint of the dramatic sound
at the point of contact above.

Wassily Kandinsky, *From Point and Line to Plane* (1926).

synaesthesia, for which music, as much as language, served as the touchstone reference.[34] But it also exhibits the drive toward systematic formalization that was characteristic of the modern sensibility that eschewed historical, literary, and mythological references in favor of an approach to "pure" form. Written from notes originally sketched in 1914, Kandinsky's work is a uniquely creative analysis of visualization. Kandinsky understood vision as a special instance of more universal theories of proportion, harmony, and number. Image and sound were correlates in his system, and the provocative language of his work, combined with its step by step analysis of the properties of points, lines, and planes, remains useful, if idiosyncratic.

Kandinsky isolated a set of primitives of visual composition that are not linked to figurative or literal references. Thus the point is the "proto-element" in his system while the dynamism of lines as forces describes rules that are simultaneously concrete and abstract. Kandinsky's conviction that principles of design crossed the boundaries of media and disciplines kept his vocabulary schematic. Though his terms work to describe visual compositions, they have a logical structure that does not depend on specific visual properties. For instance, in talking of lines, he describes principles of rhythm in terms of repetition, distinguishing quantitative and qualitative aspects of reinforcement that may be achieved in the process. His vocabulary is characteristic of the period in which he was working—references to the fourth dimension show up in words like waves and potentialities. These appear with equal fluency among other figures of dynamism. For instance, he says that the final "Goal of Theory" is to make "pulsation perceptible" and determine "wherein the living conforms to law."[35] This is a striking approach to the dynamic laws of graphic formalism.

Closely related, Paul Klee's *The Thinking Eye*, excerpts from his notebooks in the 1920s, and Laszlo Moholy-Nagy's *The New Vision* (1930) retained conspicuous traces of their artistic origins even as they straddled the traditional divide between fine arts and graphic design.[36] Modernism's codification of visual principles had begun in earnest, and at the same time, the profession of graphic design was taking shape in the context of new communications strategies, advertisement, branding campaigns, and mass market publications. Whether serving public information campaigns or private interests in the business sector, the principles of graphic communication came into sharp focus.[37] Major figures who had been part of the Bauhaus and its peer institutions dispersed to Switzerland, Italy, Britain, the United States, and elsewhere to escape Nazi persecution, spreading the principles of modern design at mid-century.[38] In the period following the end of the Second World War, key institutional players were situated in Geneva, Chicago, New York, Milan, London, and other cities, helping institutionalize an international style of highly self-conscious formal abstraction. This intellectual diaspora had the result of seeding curricula in major institutions around the world. For instance, Moholy-Nagy, whose *Vision in Motion*, published in 1946, outlined the foundation program at the Bauhaus and its extension to the Institute of Design in Chicago where Moholy-Nagy went to work



Laszlo Moholy-Nagy, *Vision in Motion* (1946).

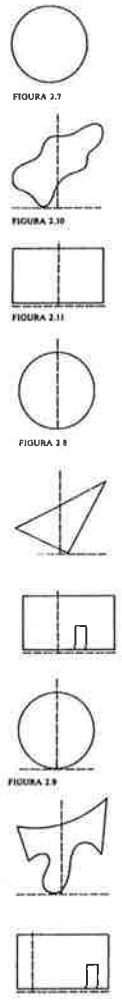
as the director in 1937.[39] The major headings of his "Contents" page make clear the integration of organic, sensual, approaches to design and those that link these to machine aesthetics. The section headings in Part II, "Design for Life," give a sense of the totalizing framework in which Moholy-Nagy is outlining his agenda in keeping with the belief that "Designing is not a Profession but an Attitude." The book identified principles of composition organized in relation to basic tenets of dynamism, stasis, order, movement, and other visual fundamentals in a manner that was becoming commonly accepted, but which had only developed through the intellectual efforts of these major thinkers in graphic design.

These texts of early twentieth century designers-turned-teachers or practitioner-theorists became the basis on which the teaching of graphic design was shaped. They were distilled into a set of principles that can be used to create effective communication in visual form. Georgy Kepes's *Language of Vision* (first published in 1944) is far more pragmatic than Kandinksy's spiritual science.[40] "Plastic organization" and "Visual representation," the titles of the two major divisions of his book, are rooted in application to concrete image-making. Other designers, such as the notable Armin Hofmann, wrote texts that outlined "principles of graphic communication" and elaborated tenets of formal visualization as compositional principles (size, scale, movement, order, symmetry, asymmetry, etc.).[41] We take all of this for granted now, but these approaches were innovative in mid-twentieth century design discourse.

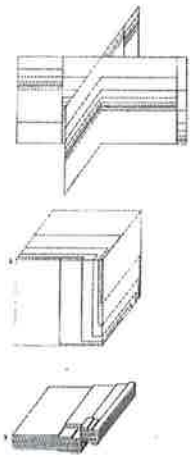
By the 1950s, it was commonplace to refer to "graphical language" or "visual communication" as if the comparison were completely natural. In 1973, Donis A. Dondis's classic *Primer of Visual Literacy* contains chapter headings like "The basic elements of visual communication" and "The anatomy

of a visual message."[42] The text describes ways that "stress" and "repose" or "levelling" and "sharpening"—among dozens of other characteristics—are attributes of visual systems that can be identified, learned, and made use of in a controlled manner. These properties come to seem self-evident as a result, and the assumption that they inhere in a graphical object goes unquestioned. Dondis's book distills the fundamentals of communication into a clear vocabulary accompanied by schematic images that illustrate basic principles from shape, direction, balance, and motion, to applied principles of predictability/spontaneity or understatement/exaggeration. The lessons are designed for use in the studio, and offer a systematic introduction to graphic composition and visual communication. Neither irony nor self-conscious historical inflection are present, and the text reads with all the confidence of any other technical manual.

Publications on the laws of form, principles governing visual communication, became the standard graphic design manuals in the 1950s and 1960s. Swiss design, with its ordered grids and formal rules, so suited to later wire frame design in onscreen environments, was directly influenced by the Bauhaus through teaching and/or personal connection. Max Bill, Karl Gerstner, and Josef Müller-Brockmann published widely.[43] Gerstner's 1964 *Designing Programmes* announces the ways conceptual work, graphic design, systems theory, and information were beginning to converge.[44] Gerstner outlined a radically new approach to generating form through step-by-step procedures. He saw that designers must be prepared to create programs, not just understand composition and formal properties of graphics. More rigid than Kandinsky or Klee, the Swiss designers popularized the grids and stylistic features of a streamlined, functionalist approach based on a conviction that effects could be controlled, pre-



Donis A. Dondis, *Primer of Visual Literacy* (1973).



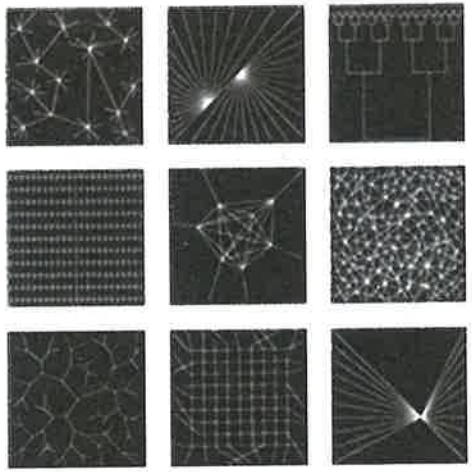
Karl Gerstner, *Designing Programmes* (1964).

dicted, and produced in accord with rules that could be made explicit. Handbooks for graphic design teaching provided a structured approach to learning lessons of size, scale, texture, orientation, and other compositional principles. Anton Stankowski's daring *Visual Presentation of Invisible Processes* exemplifies graphic design practices that were suited to information display and analysis, even as the world of information visualization and data graphics was exploding in the high-style pages of *Fortune* magazine, *Forbes*, or in the manuals designed to guide the creation of statistical charts and graphs.[45] Like Gerstner, Stankowski pushed graphics into a dialogue with processes that were not inherently visual. If Gerstner used programmatic means to generate graphics, Stankowski used graphic means to express programmatic systems and conditions. The algorithmic sensibility was clearly on the horizon.

Gestalt principles and tendencies

Theoretical study of graphical elements and principles developed somewhat differently in art history than design, at the intersection of cultural anthropology, psychology of perception, and abstract form. Wilhelm Worringer's *Abstraction and Empathy*, published first in 1907, put forth a basic analysis of geometric and organic graphical motifs that is not far from Walter Crane's.[46] Worringer's thesis was that hard-edged, geometric forms emerge in cultures whose relation to the natural world is fraught and difficult, while sinewy curves are found among those in more harmonious circumstances. Worringer's work was highly influential. Carl Jung took some of its principles into his own analysis of symbols and symbolic forms, convinced by the argument for

specific inherent meaning in icons and images.[47] Worringer's thesis may have been reductive, even essentialist in its claims, but it laid a foundation for consideration of what the elaborate system-maker, Ernst Cassirer, explored across his multi-volume study *Philosophy of Symbolic Form*, published between 1923–29, namely the conviction that forms have value—and that these values have a highly symbolic resonance.[48]



Anton Stankowski, *Visual Presentation of Invisible Processes: How to Illustrate Invisible Processes in Graphic Design* (NY: Hastings House, 1967).

The study of visual perception that resulted in Gestalt principles emerged in studies of psychology in the 1930s.[49] These studies of tendencies of visual form to produce predictable effects had been sparked by the findings of a philosopher, Christian von Ehrenfels. His influential 1890 publication, *On the Qualities of Form*, had reported the observation that a melody's structure, not its specific notes, gave it a distinct formal identity, hence our ability to recognize it across different keys.[50] This principle of "grouping," perhaps better described as a configuration, became the foundation of the work of Gestalt psychologist Max Wertheimer and his collaborators Kurt Koffka and Wolfgang Köhler.[51] Their experimental studies in perception established the existence of certain tendencies in human visual perception. The basic Gestalt principles, proximity, similarity, closure, continuation, common fate, and good form, work in screen environments as well as in print and paper ones.[52] The theorist Rudolf Arnheim studied with the three prominent Gestalt psychologists

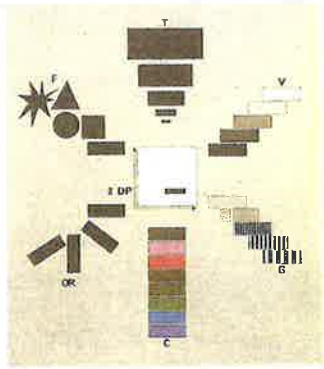
and articulated their principles in his renowned *Art and Visual Perception*, originally published in 1954.[53] Arnheim's treatise is thorough, its application to the visual arts is explicit, and its influence as a text inestimable. The chapter titles show the exhaustive range of his approach: Balance, Shape, Form, Growth, Space, Light, Color, Movement, Dynamics, and Expression. While rooted in perception, the book also became the standard reference for books guiding production. Elaborate as the examples, topics, and issues are, they are in essence reducible, as Arnheim himself states, to "the basic law of visual perception: Any stimulus pattern tends to be seen in such a way that the resulting structure is as simple as the given conditions permit."[54] [See Window 2, Gestalt diagrams]

Basic variables and semiotic approaches

Formalist principles undergird all structuralist and semiotic approaches to the study of form.[55] No text outlining strict structuralist principles in graphic systems (as distinct from the formal approaches of Kandinsky and Klee that emerged in a very different context) was written in the early decades of the twentieth century, though the Russian linguist Roman Jakobson, among others, would later take formal principles derived from the study of poetics into analysis of distinctions between verbal and visual arts.[56] Other early twentieth century semioticians used their linguistic analogies to analyze all manner of cultural practices, including visual ones, but did not create the kind of metalanguage for describing graphics that came from kindred spirits (and sometimes friends and collaborators) working in design in the same period. Semioticians and structuralists struggled to find the basic codes of visual form and

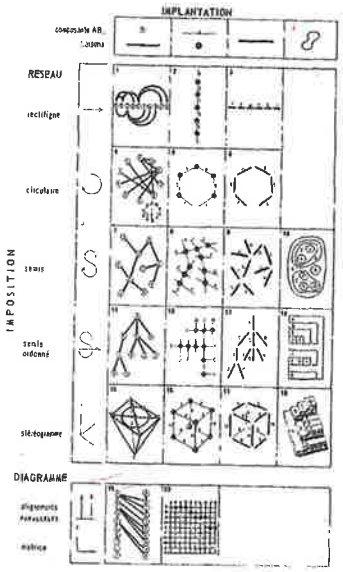
only brought these efforts to fruition in the 1960s.

Working through the tenets developed in Russian formalist linguistics in the 1910s and 1920s, Prague School semioticians Juri Lotman, Jan Mukarovsky, and others endeavored to create "systems" for analysis of ritual and performance that could extend Saussurean linguistics to cultural practices.[57] The Prague School's semiotic analyses of fashion and folklore took formal analysis into the realms of culture, including visual culture. These various formalisms divide between those that believe in an inherent quality of graphical expressions themselves (affective qualities of line, shape, movement) and those that are structuralist in their approach to the value of graphic signs in a conventional system (semiotics). Graphical signs trouble the distinction between inherent and conventional meaning production. A diagonal line, for instance, does not represent the angle at which it is drawn, it enacts and embodies its dynamic qualities. But the color red may carry a symbolic value that differs radically across cultures.



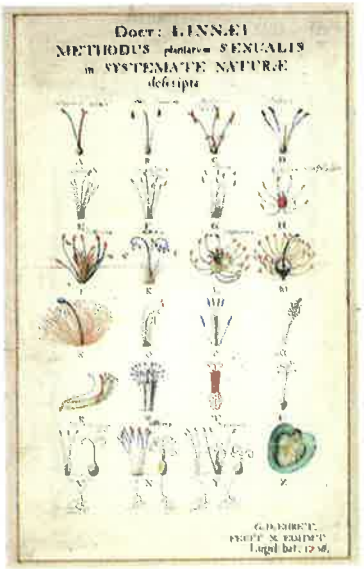
Jacques Bertin (with Marc Barbut et al.), basic graphic variables, *Sémiologie Graphique. Les diagrammes, les réseaux, les cartes* (Paris: Gauthier-Villars, 1967).

Aesthetician and philosopher Nelson Goodman, whose *Languages of Art* was a late twentieth century classic, proposed systematic tenets for analysis of graphic and pictorial elements.[58] The semiotics of visual forms also found enthusiastic reception from cartographers for whom knowledge and manipulation of basic graphic variables is an essential part of their production. The stabilization of graphical conventions in cartography was driven by needs specific to the profession, but it created insights that can be transferred to other fields. Jacques Bertin's *Semiology of Graphics* (*Sémiologie Graphique*), first published in 1967, embodies a mature ap-



Jacques Bertin (with Marc Barbut et al.), taxonomy of network diagrams from *Sémiologie Graphique. Les diagrammes, les réseaux, les cartes* (Paris: Gauthier-Villars, 1967).

proach to structured analysis of graphical systems for use in design production.[59] Bertin isolated seven variables of static graphics—shape, size, orientation, color, tone, texture, position—and elaborated their considered use for representing cartographic and geographic information. His insights have been adopted by information designers in static and dynamic media, with additional variables (such as rate and direction of movement) specific to the capacities of digital platforms. Assigning statistical variables different roles in a rational way—such as using color to designate intensity, size to show quantity, texture or pattern to another attribute, and so on—gives control over the production of semantic value. In her synthetic work, *Semiotics of Visual Language* (first published in French in 1987), Fernande Saint-Martin presented a more generalized system than Bertin's (which was intimately bound to cartography).[60] The terminology in her table of contents reflects her absorption of the full spectrum of twentieth century writings from a formalist perspective. She begins with "The Basic Elements of Visual Language" and proceeds through such topics as "Syntax of Visual Language" and "The Grammar of Sculpture," and so on. She argued for a concept of the "coloreme" as an equivalent to the "phoneme" in language—the smallest unit of significant meaning production—though, tellingly, the notion did not find widespread acceptance.[61] More pragmatic approaches, less reflexive perhaps and fraught with assumptions, proliferate in books like Robert Horn's *Visual Language: Global Communication for the 21st Century* or the more recent work by Connie Malamed, *Visual Language for*



Georg Dionysius Ehret's illustration of Linnaeus's sexual system of plant classification (1736); with permission from the Linnean Society of London.

Designers.[62] Useful as manuals of instruction, as well as analysis of visual principles, such works gloss their structuralist roots and formalist assumptions in favor of providing basic tools for production. The number of titles of text books, design manuals, books meant for trade and school, for artists and designers, that contain some reference to "language" as a part of their systematic approach to form grew substantially in the late twentieth century.[63] Somewhat tempered by issues of ethics, political and social conscience in design, and cultural studies approaches to analysis, the tenets of Gestalt psychology, semiotics, and formal composition remain standard elements of design practice, still applicable to contemporary work.

[See Window 3, semiotic principles and graphic variables]

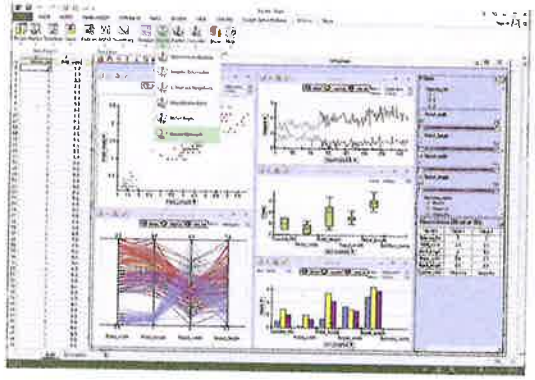
Visual editing/framing and reading

The study of visual elements and systems in formal terms gets augmented when it meets the analysis of narrative sequences and editing practices. Scott McCloud's pioneering work in analyzing comic books and graphic novels provides a useful description of the ways relations across frames can be structured and read.[64] McCloud's approach focuses on the ways graphical frames organize story elements into sense and narrative. The multi-modal and intermedia environments of online viewing require much frame-jumping and shifting, and the overhead on cognition is in large part caused by the way we read the graphical presentation of materials with dif-

ferent requirements for intellectual processing.[65] The transitions that McCloud outlines establish relations between frames (character, place, event, time, story, point of view, detail, and jump) and find their echo in the description of film and video editing. To what extent are the frames in interfaces different from those in comic books and films? Interfaces are spatial and graphic in their use of frames, but these are not necessarily in the service of narrative—rarely, in fact. But film/video, comics, and graphic novels are story-telling forms and the relations across their frames are most frequently used to produce continuity. Random access through motion picture graphics in games, hypertext film, database documentaries, is altering the approach to composition and analysis.

[See Window 4, McCloud and editing principles]

Web environments not only make use of interactive and dynamic graphics, with sliders, time-lines, and animation, but also create spaces in which montage principles and editing techniques used in narrative come into play. The invention of cinema in the early years of the twentieth century introduced time and motion to visual images, as well as the challenge of creating effects across cuts in the celluloid strip. The development of theories of montage bifurcated into those focused on narrative continuity that dominated Hollywood and other entertainment industries, and those that engaged the exploration of experimental montage, such as the Soviet filmmakers Sergei Eisenstein and Dziga Vertov.[66] Eisenstein's "montage of attractions" methods included



Cross correlations visualized with Pathway Architect text mining software (2011).

metric, rhythmic, tonal, associational, and intellectual (suggestive and symbolic) montage that emphasized both abstract and emotional effects, rather than linear storytelling. Vertov's machine aesthetic was more radical, defamiliarizing, and unfamiliar as a utopian view, and his formalist approaches stressed mechanical motifs. While focused on the literal content of film images, including graphical and formal properties, montage is based on what Roland Barthes termed the "third meaning," or what occurs across images, rather than simply within them.[67]

Editing techniques divide into linear and non-linear approaches, those emphasizing continuity of story through illusions of realism and those that rupture such illusions. Editing techniques have become codified in film schools and video editing classes, whether to optimize realist illusions or to signal avant-garde and innovative departures from standard narrative. Because web environments are dynamic, it is tempting to take the basic language of motion picture editing and create analogies for each kind of shot (close up, establishing, tracking, detail, mid-range, pan, following, and so on), or transition between shots (cheat cut, parallel edit, cut away, dissolve, iris, jump, superimposition, wipe) match across shots (eyeline, action, motion, scene, wipe, shot-reverse-shot, dissolve, jump-cut, etc.), or duration (long shot, overlapping, elliptical, simultaneous). But to reiterate, film editing relies on narrative theory, not just visual principles of perception, and the principles of temporal change, motion, animation, and dynamic graphical means are essential to its production. Web environments force cognitive processing across disparate and often unconnected areas of experience and representation. They frequently require multi-modal processing of varied media. A whole new set of challenges for describing these relational dimensions

Harold Cohen, AARON, principles and demonstration (1979).

arises as a result. As we have seen, between the first decade of the twentieth century and the third, the broad outlines of visual epistemology came into view. From these, semiotic, structuralist, and formal articulations based on the metaphor of a language of graphical means were developed. While theories of vision (these have their own related, independent history) and, even more, those of optics (the science of light, color, and instruments) belong to the history of scientific investigation of the physiology of sight and the phenomena of the visual world, the study of Gestalt principles, design and compositional rules, and visual tendencies are rooted in interpretative activity.[68] The humanistic aspiration to imitate scientific systematization is linked to a modern attempt to develop universal principles, tenets that would obtain in all cultural and historical circumstances. Like structuralism's central principles about systems and values, these assumed that universal principles might transcend their embodiment in instances or expressions. That this is itself an expression of a historical moment, particularly and specifically modern, does not necessarily negate the principles themselves. An eye looking at a line drawing a round shape that nearly closes on itself will tend to see a circle under many circumstances, just not all. One of the questions that arises in contemporary context is whether a machine can be taught the same principles of analysis or production. The task of abstracting principles that can be used for instruction is quite a different matter when a machine, not a human being, has to be trained. In a computational system, every instruction must be explicit, and no experience of the life-world or body can be drawn on in the process.

Computational processing for analysis and production

The idea of using computers to draw, sketch, or present information in graphical form arose with mainframes and plotter pens, but the task of imagining computer vision is even more difficult. The two have a common interest in identifying graphical primitives, whether for production or for analysis. The pioneering work of Harold Cohen serves as one major example.[69] His automated drawing partner, AARON, the platform on which Cohen worked out his systematic approach to visual composition as a set of ways of thinking about figures, grounds, composition, occluded objects, and points of view, serves as one major example of an attempt to build a visually epistemic machine.[70] Most graphical systems for production are based either on pixel values (the tapestry approach) or vector graphics (shapes stored as mathematically described lines, angles, and relations). These lend themselves to computational processing. But Cohen programmed AARON with primitives about the visual experience of the world—trees, faces, landscapes were described as rule sets governing image production.

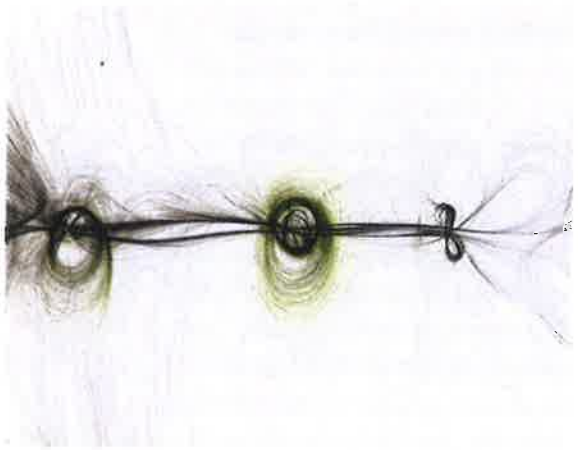
A very different challenge arose in the design of drawing and painting programs. These had to choose between an analysis of graphic formal primitives (line, fill, texture) and that of production behaviors (stroke, rub, stipple).[71] More recently, specialized programs aimed specifically at the needs of visual and graphic artists have resulted in numerically based approaches, such as the *Design by Numbers* of John Maeda and the Processing language developed by Ben Fry and Casey Reas.[72] As data visualization has advanced, it continues to draw on traditions of charts, graphs, diagrams, trees, and maps to which we will turn our attention in a moment,

Casey Reas, code and output developed with Processing programming language.

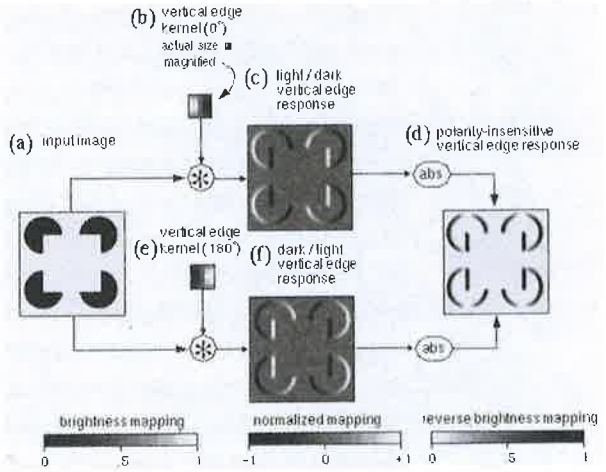
though of course production operates in computational environments and on graphical displays that are screen-based, rather than print-based, with all the accompanying shifts in aesthetic style.

Graphical primitives also underpin the approach to artificial vision put forth by David Marr in his 1982 book, *Vision: A Computational Investigation into the Human Representation and Processing of Visual Information.*[73] Marr's analysis incorporated somewhat different founding principles than those of the semioticians and cartographers. He was analyzing visual processing, not graphical forms, and so attempted to create a computational model for the ways in which seeing produces differential data for cognitive understanding.

Marr's primitives were very different from those of his predecessors in the graphic arts, and more directly related to models of vision and cognition in neurobiology and psychology. In addition to the three parts of his model—computational, representational, and physical—he described several stages in the realization of visual processing that moved from what he called a primal sketch to a two and ½ dimensional sketch and then a final three-dimensional model. The significance of this for our discussion of the languages of graphics is the way he separated edge detection, form recognition, surface treatment, and texture from shape, motion, and depth. Marr broke new ground through such syntheses, and defined



visual primitives in terms of the operations through which each property can be processed. He showed that different features of a single image could be isolated and described independently, so that attributes like texture or color were separated from shape or orientation.[74]



Though many details of Marr's early and posthumous work have been revisited since its publication, its place as a computational theory of visual perception has been questioned and superseded. Artificial vision, whether for analysis or production, still faces daunting challenges. The complexity of visual means of knowledge production is matched by the sophistication of our cognitive processing. Visual knowledge is as dependent on lived, embodied, specific knowledge as any other field of human endeavor, and integrates other sense data as part of cognition. Not only do we process complex representations, but we are imbued with cultural training that allows us to understand them as knowledge, communicated and consensual, in spite of the fact that we have no "language" of graphics or rules governing their use. What we have are conventions, habits of reading and thought, and graphical expressions whose properties translate into semantic value—in part through association with other forms and in part through inherent properties. [See Window 5, David Marr and modelling vision]

Steven Lehar, computational implications of Gestalt theory, figure 4.

From formal languages of graphics to graphic formats

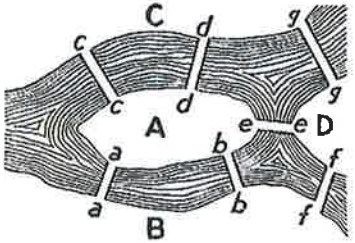
The terms on which formalization occurs are many, as we have seen. In this brief overview, the first examples were of an approach to understanding the affect of graphics, in the work of Superville and others, for whom the emotional, communicative impact was paramount. The early twentieth century modernists, searching for universals, outlined an inventory of effects they believed were absolute, rule-governed, and applicable in all instances (e.g. Crane, Kandinsky). These gave rise to conventions and rules of composition that became the foundation of graphic design curricula and the practice of visual communication (e.g. Dondis, Horn, Moholy-Nagy, Kepes). Contributing to this development in parallel, Gestalt principles were articulated by psychologists interested in perception (Wertheimer, Arnheim). Semioticians took up formal analysis at the intersection of these approaches and created a systematic analysis of elements at the disposal of designers of information graphics, maps, and web environments (Bertin, Saint-Martin). As digital technologies engaged with visual practices, artists and computer scientists engaged the analysis of images to discern the primitives of production and of reception (Cohen, Marr). These formal investigations continue, even as the need for methods suitable to humanistic representations push at the limits of formal means. Obviously, these are not the means required for web interfaces across the board, only within specialized domains where the materials and approaches stress observer-dependent knowledge, interpretative approaches, and depend on our ability to express ambiguity and contradiction. The design of interface and information visualizations (the focus of a coming chapter) has made use of these intellectual

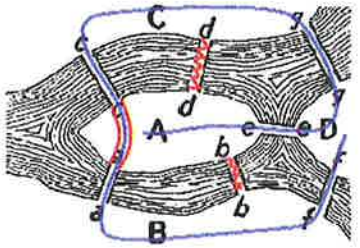
traditions while adding its own contributions to the field of knowledge design and graphical form.

This overview of approaches to formal principles of visual communication only skims the surface of a rich history. But the survey demonstrates the existence of carefully thought out foundations on which visual forms of knowledge can be understood. The systematic analysis of "graphical language" remains crucial, its principles are the fundamental basis of graphesis. But they are not its end goal, which is the analysis and imaginative production of visualizations, visualized interpretation, and graphical user interfaces.

Going ahead, we will examine the common forms and conventions used for information visualizations. These often have their origins in antiquity, though many others have come into being more recently to serve modern interests or express computational processes. Our examples draw on long-standing conventions in Western culture and representation. Some of these examples have counterpoints in other cultures—an abacus uses its place-holding apparatus to construct numerical value as surely as columns on balance sheets, tree diagrams have as near a universal presence in ancient cultures as in present ones, and calendars based on a wheel that matches the rotation of the skies with the cycles of the year arise from observations in most indigenous cultures. But other graphical modes are culturally or historically specific. Concepts of fluidity, motion, dynamism that stress ways into and out of a space of graphical composition are more highly privileged in Eastern culture, for instance as opposed to the centralizing symmetries and orderings of the stable picture plane or coordinate mappings of space. In the future, cultural exchanges may result in far more robust and nuanced solutions to our need for interpretative graphics in the humanities.

At the farther edge of speculation, we can approach the



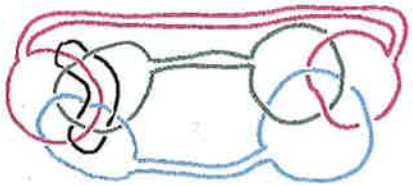


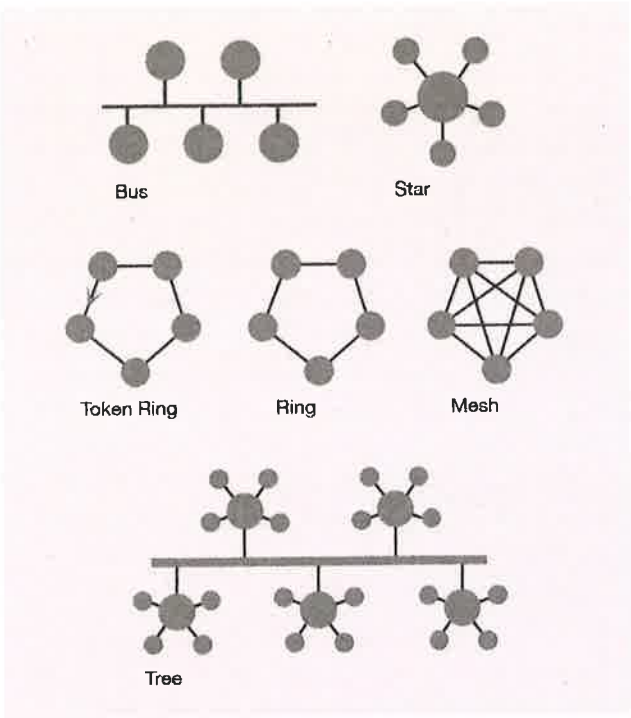
Leonhard Euler's drawings of the Königsberg Bridge problem; from his "Solutio problematis ad geometriam situs pertinentis," *Comment. Acad. Sci. U. Petrop.* 8 (1736): 128-40.

Stephen Wolfram's analysis of the Königsberg Bridge problem.

analysis of graphical forms expressing interpretation through a poetics of relations, with its combination of inflected values and attributes—of hierarchy and juxtaposition, entanglement and embeddedness, of subordination and exchange, and other properties that will be invoked in the discussion of diagrammatic writing in electronic space. Leonhard Euler's struggles with a long-unsolved problem in spatial logic, the Königsberg Bridge problem, established what he called "a geometry of position, not of measure" as a foundational principle.[75] Nineteenth century mathematicians used the word topology, struggling for a language to describe the connectivity of surfaces. Topological vocabulary might well apply to the study of textual structures and paratextual apparatuses and the relations of marginalia, footnotes, margins, columns, spaces, indentations, headers and footers. Theories of editing that engage with continuity and discontinuity are fundamental to reading the rhetorical operations of hyperlinked environments, but we still have a challenge in creating a metalanguage for the ways graphical forms express relations in the extensible space of the screen, and become part of the information of the text through their structuring effects. All graphical schema are built on the single principle of defining classes of entities and of relations. For a humanistic approach, these have to be defined as rhetorical arguments produced as a result of making, a poetics of graphical form, not in the reductive or abstract logics of Boolean algebra. In a humanistic environment, And, Or, and Not, for instance, carry an almost infinite number of qualifying attributes that

make each instance distinct. When graphical languages engage with poetics and rhetoric, we will have arrived at a fully humanistic system for visualizing interpretation. For the present, let us turn our attention to the study of graphical forms in information visualizations and interface designs.



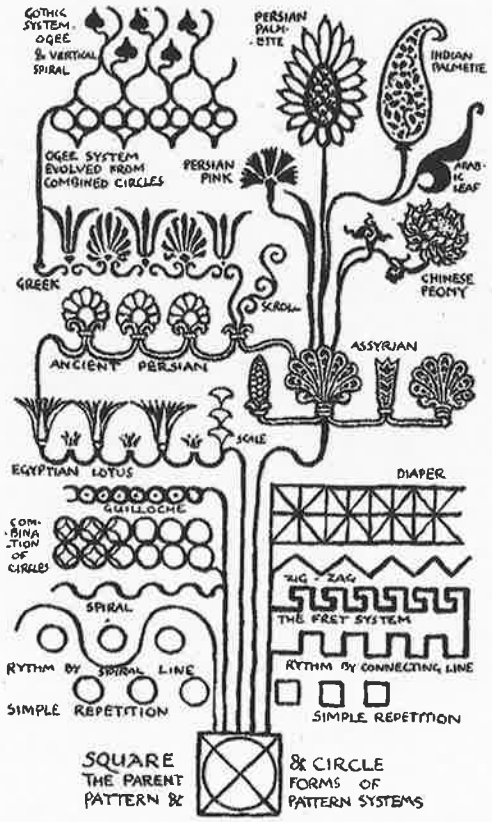


Jacques Lacan, drawing of "The Analytic Situation" (Jan. 14, 1975), quoted from the website of P.L.A.C.E.

Basic topological structures.

Walter Crane's tree

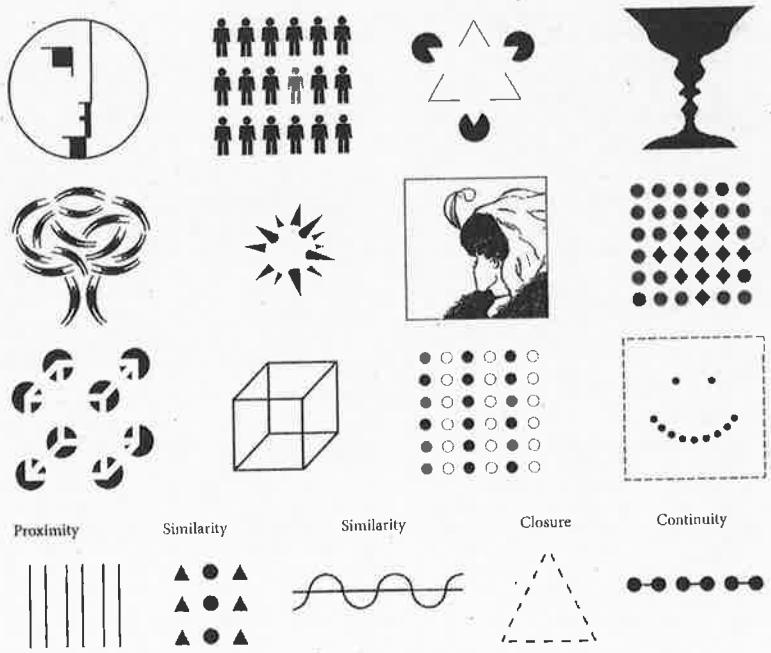
The artist's lively imagination synthesized all the world's decorative motifs into a single tree of pattern systems. The image combines a wealth of specific forms—the Chinese peony, Egyptian lotus, and Arabic leaf among others—with an introduction to basic elements of design. The circle and square form the base—as the *alpha* and *omega* (or "parent forms") —of graphic language from which all other elements can be made.



Crane, *Line and Form* (1900).

Gestalt diagrams

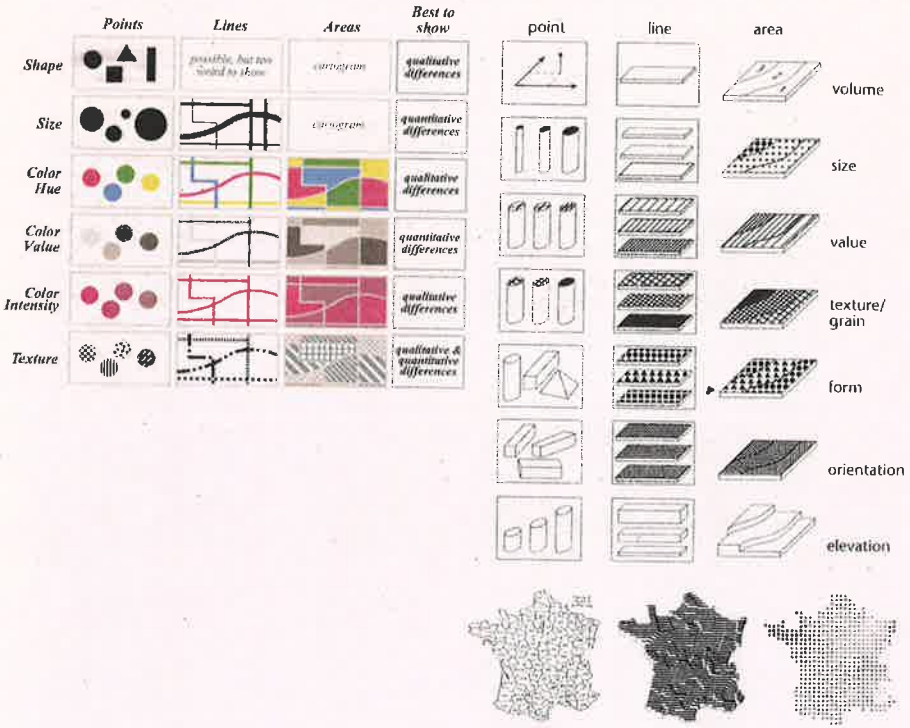
The term "gestalt" refers to groupings and our tendency to see patterns wherever possible. Human perception isn't literal. We will close gaps, see motion, make partial shapes into whole ones in ways that are surprisingly predictable. Biologists who study perception refer to the "ecology" of vision—ways our visual processes favor needs or tasks essential to our survival. Such ideas counter the old "representational" approach to vision as a "picture in our heads," and replace it with constructivist notions. We don't simply *see* what *is* in a mechanistic way. Instead, *what is seen is what is made.* Instead of talking about pictures and images, we describe visual activity in terms of affordances and processes.



Gestalt diagrams, various sources.

Graphic variables

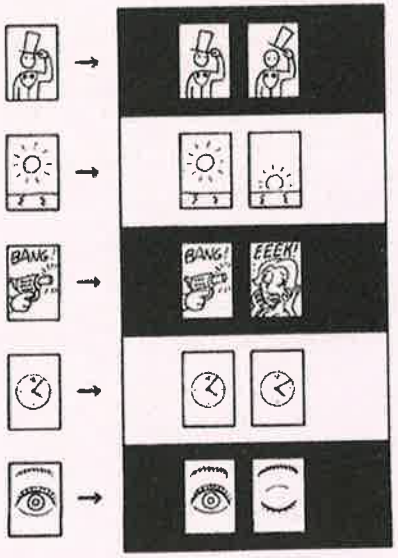
The cartographer Jacques Bertin identified basic graphic variables for use in mapmaking. His systematic approach has been extremely useful for design in many other fields. The chart below is lacking one of the seven: orientation. This chart neatly summarizes the variables and the best use that can be made of them. Though Bertin's approach, rooted in semiotics (the study of sign systems), was highly rational, it can be used in playful and imaginative ways as well as in highly professional, controlled applications, such as the ones we see in these examples below.



Jacques Bertin, graphic variables, *Semiology of Graphics* (1967).

Making connections

Human beings read sequences of images and make sense of them. Comic book artists, film editors, web designers, and graphic novelists all know intuitively how to make connections among images, but Scott McCloud's pioneering work on the graphical structure of comic books offers a systematic description of ways meaning is produced across images. Theorist Roland Barthes used the phrase "the third meaning" to point to the effects of film editing, citing the great Soviet director Sergei Eisenstein as an example. Eisenstein's own work, *Film Form*, is a classic text on editing.

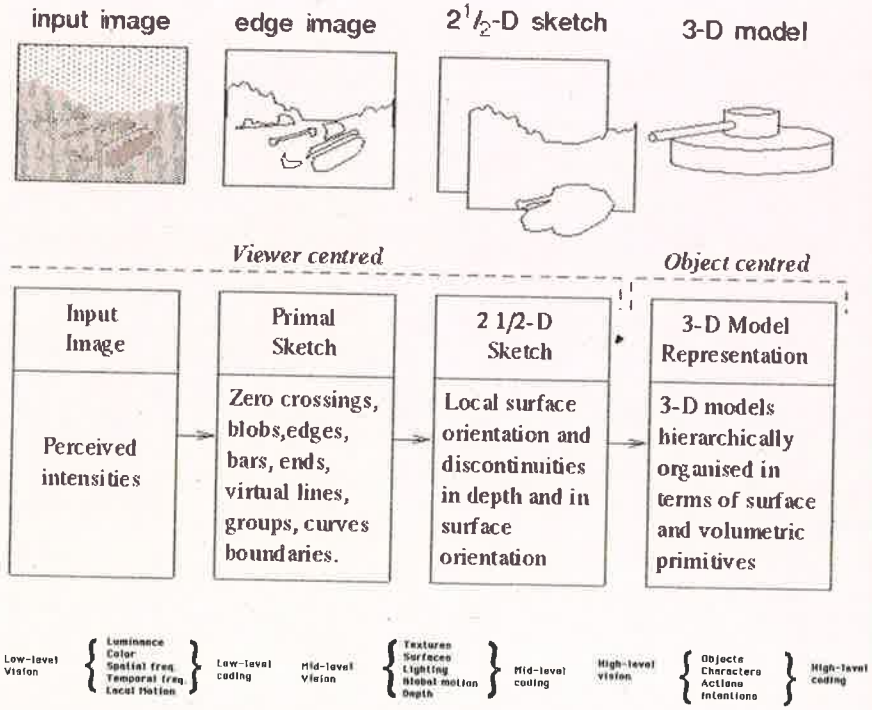


Scott McCloud, editing conventions, *Understanding Comics* (1994).

Sergei Eisenstein, stills from *Battleship Potemkin* (1925).

Modelling vision

The computer scientist David Marr created one of the first models of vision for artificial visual intelligence programming and processing. Trying to teach a computer to process visual experience raised new challenges. Marr had to model the process by which we take in information in visual form. He created a system that could be translated into a computer-driven decision tree by looking at edges, overlaps, surfaces, and other features. His goal was to create the foundation for artificial vision and computational processing of images.

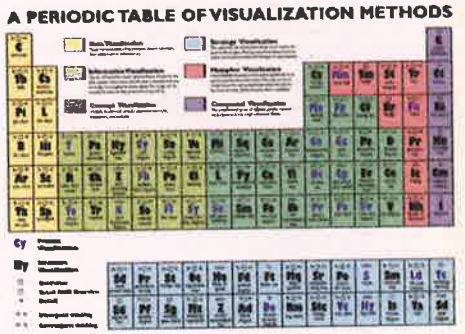


David Marr, modelling vision, *Vision* (1982).

Information visualizations

A site like the IBM-sponsored *Many Eyes* offers a useful suite of tools for turning data sets into the most common visualization types and also provides some basic guidelines for selecting visualizations appropriate to the task at hand. This lively chart is interactive on the web. It shows traditional print graphics alongside computer generated visualizations. Created by Ralph Lengler and Martin Eppler, it provides a clear roadmap for exploration of the world of information visualizations.

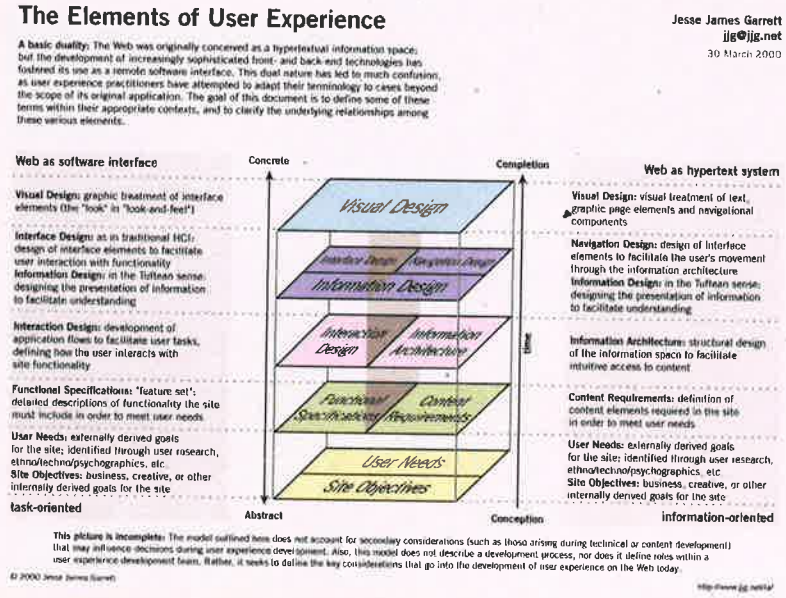
Many Eyes, information visualizations.



A periodic table of visualization methods (2007).

Interface design

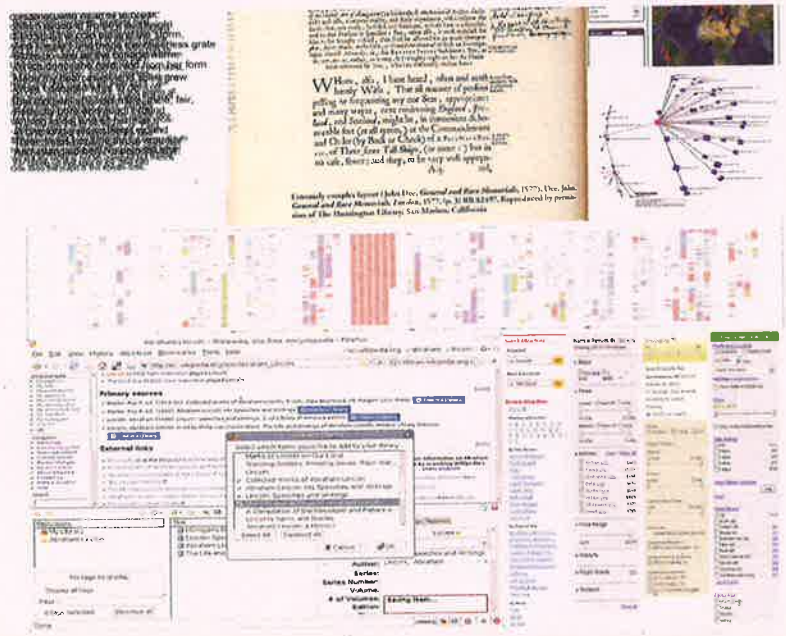
An interface can show information or it can support tasks and behaviors. Jesse James Garrett's oft-cited chart shows the tensions between these two different approaches to the design of the "user experience." Understanding the trade-offs between information and task-oriented strategies and the implications of picking between them is crucial to effective interface design. Adding humanistic values to the ways interfaces structure critical insight is also essential, allowing for contrast, comparison, and exposure of the act of making meaning rather than simply presenting options on a menu. Humanistic interface is in its infancy, but can build on these precedents.



Jesse James Garrett, elements of the user experience (2000).

The "book" of the future

The "book" of the future will combine reading and writing, annotation and social media, text processing and analysis, data mining and mind-mapping, searching and linking, indexing and display, image parsing and distant reading, in a multi-modal, cross-platform, inter-media environment. Pages will be temporary configurations based on calls to repositories and data sets. We will "publish" our data trails as guidebooks for the experience of reading, pointing to milestones and portals for in-depth exploration of stories, inventories, and the rich combination of cultural heritage and social life in a global world. The display will take advantage of the n-dimensional space of the screen in ways that combine multiple design visions.



A future multi-modal book.