

Icons and Intelligent Icons: How Compactness and Adaptability Advance the Utility of These Devices (Part I)

WILLIAM M. BEVINGTON, PIIM
DAVID FUSILIER, BFA

KEYWORDS *Iconography, icons, ideograph, information theory, informative visual representation, intelligent icons, pictograph, quantigraph, signified, signifier, signifier key, symbols, VT-CAD*

ABSTRACT The lack of rigid descriptive standards in the field of visual communications have led to fairly ambiguous definitions for some terms. Labels such as *pictograph, symbol, or icon* are used interchangeably; when additional descriptive refinement is added to these base terms, such as in the case of “intelligent icon,” the uncertainty of meaning is compounded further. This article provides general functional definitions for the terms icon, and a specific definition for intelligent icon. Such functional definitions assist practitioners in the design process. This will lead to improving the retrieval, display, and assessment of data through visualization—in turn, yielding improved decision making for knowledge workers.

Concisely, we assert that *icons* are: highly informative visual representations composed of symbolic (pictographs, ideographs, etc.) and/or *quantigraphic* elements (devices that convey numeric or statistical data); further, to be considered truly *intelligent*, icons must be: *unconstrained* (informatively self-contained), *compact* (conveying dense levels of information within a very small footprint), and *adaptive* (dependent upon and changing to reflect data specificities from which they are generated). This argument will be supported through a carefully articulated taxonomy and flow diagram that considers the nature and function of intelligent icons within the communication/information design fields.

ICONS AND THE VT-CAD SYSTEM

An earlier PIIMPAPER proposed a taxonomy for the *classification, analysis, and design* of informative imagery. The initial objective in creating the taxonomy was to derive root spatial patterns that were consistently found in every informative visual representation. Next, to see how these patterns (individually or in combination) supported the tangible display of any kind of data. The theory is referred to as VT-CAD (The *Visual Taxonomy for the Classification, Analysis, and Design of Informative Visualization*). This theory/tool resulted from an exhaustive, decade-long investigation by William Bevington, then, through the refinements of multiple contributors, principally Dr. Arno Klein (currently serving as an Assistant Professor of Clinical Neurobiology, Division of Molecular Imaging and Neuropathology, New York State Psychiatric Institute, Columbia University, NY) the logic was further refined. (This article addresses some further refinement to the theory). [see endnote]

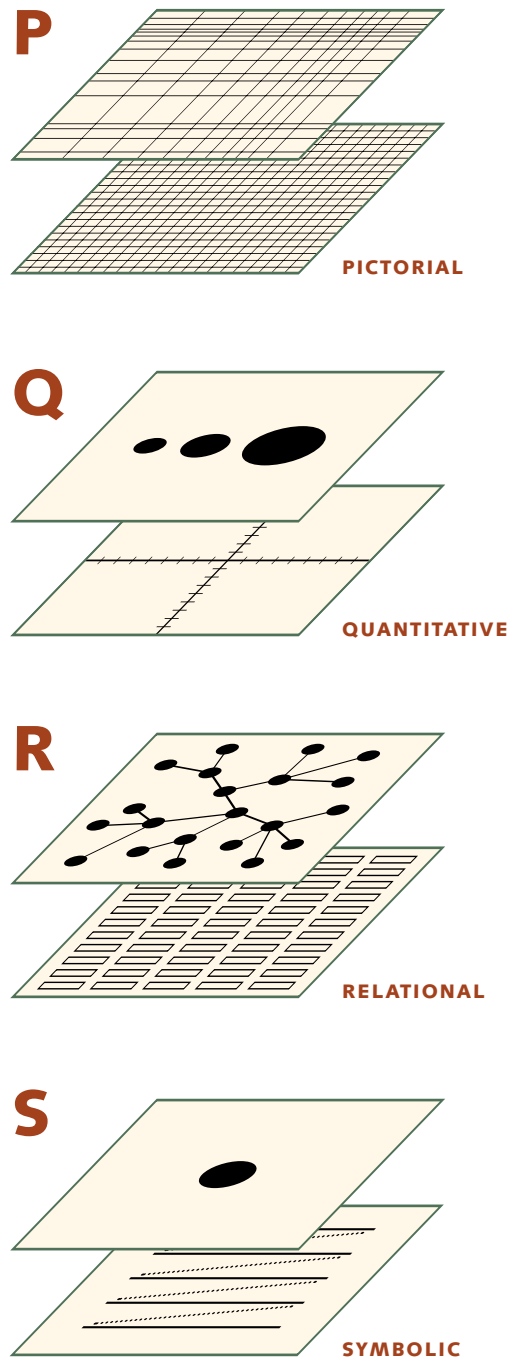


FIGURE 1: All visual representation is rendered through one of four modeling classes: Pictorial, Quantitative, Relational, and Symbolic (P, Q, R, S). They may be utilized individually or layered collectively. Each class has both a constrained and an unconstrained variant, sometimes the pattern “organizes” the visual representation; sometimes the pattern “is” the representation.

In all, four classes were identified: *Pictorial* representations, *Quantitative* representations, *Relational* representations, and, *Symbolic* representations (*P, Q, R, S*). Within each of these classes two subclasses were found resulting in eight key patterns. Patterns may be: unconstrained or adaptive, semi-constraining, or constraining. *Unconstrained or adaptive* representations are “free” patterns that deploy subjective design and organization logic in order to convey informativeness—irrespective of relationality. *Constraining and semi-constraining* representations convey informativeness through relationality. In order to understand this visual taxonomy it is useful to discuss the eight types individually and as succinctly as possible.

PICTORIAL REPRESENTATIONS

Pictorial representations may range from extremely accurate state-of-the-art sensor-collected imagery (such as earth images collected through high-resolution satellite photogrammetric methods) to myriad contrived and free-form images (such as caricatures and “rough” sketches). In the first pictorial subclass—constrained (which are in themselves constrained and may function to constrain other elements)—accuracy to earth’s reality is paramount, there is no emphasis of features, *per se*, as accuracy dictates precise interrelationship. In the second subclass of everything else pictorial—features are dropped, exaggerated, or ridiculously exaggerated to engender a cognitive viewpoint. These would be semi-constrained (or semi-constraining images). Such pictorial imagery may stand alone or it may position many other types of supporting visual elements upon it. When a visual representation serves to organize other visual data types, it may be referred to as a *basemap*. Basemaps may visible or non-visible even though they serve to position elements. Unconstrained elements are generally in a *superfice* position. A *superfice* must, by definition, be visible. Further, pictorial representations may be generalized, simplified, or decontextualized to the point at which they become fully unconstrained—thus becoming symbolic representations. *Pictorial representations contain too much detail, and their size, or compactness will preclude this class from advancing toward intelligent icon status.*

QUANTITATIVE REPRESENTATIONS

Quantitative representations depend on specified distances and use a spatially relational organizing structure of Cartesian space—constrained (or constraining). There are also unconstrained or adaptive aspects within quantitative representations as numeric values may simply be supplied by shapes. In *VT-CAD*, these quantitative icons are called glyphs, in this paper they are termed *quantigraphs*. Because quantigraphs are unconstrained, they may be placed over any constrained pattern in order to render relational intelligence. *In most cases quantigraphs can be considered icons; however, most do not jump all the hurdles of compactness and adaptiveness in order to be considered as intelligent icons because their size often determines value. A device that needs to be larger to signify, say 10,000, and smaller to convey, say 100, would not possess inherent compactness. In either case one can see how distance plays a representational role toward quantitiveness.*

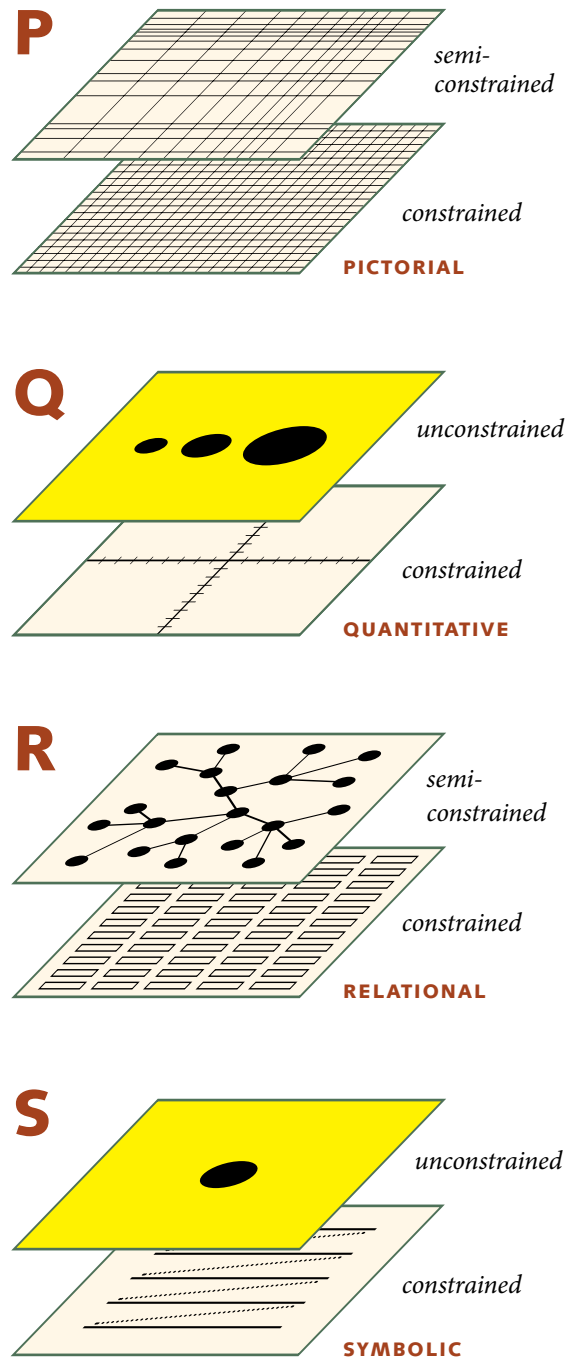


FIGURE 2:
Icons (shown in the two highlighted class variants above) are unconstrained. In their quantitative form they may be referred to as quantigraphs. In their symbolic form they are generally pictographs or ideographs. Regardless, they are generally positioned by any of the constrained or semi-constrained class variants.

RELATIONAL REPRESENTATIONS

Relational imagery is also of two broad kinds. One type falls into the spatially constraining format—columns and rows, and tables of cells. The other is unconstrained—as can easily be seen through link and node diagrams. The nodes within the “link and node” diagrams may themselves be icons of some kind. So the link and node diagram is itself unconstrained even though it too can constrain other data. This “cycle” of constrained and unconstrained will be discussed in detail within this paper. *Relational networks do not generally function as icons, and spatial and contextual considerations (compactness) prevent them from achieving intelligence.*

SYMBOLIC REPRESENTATIONS

Symbolic representations can be considered as “singular elements” that either stand alone (as unconstrained or adaptive devices) or need be composed in a group in order to convey meaning (constrained, e.g. as common text settings). Constrained symbols that must be combined for sense-making are generally not eligible for intelligence because they lack compactness. *However, Unconstrained symbols or adaptive devices (ideographs, pictographs, and sometimes quantigraphs) may be used as icons and are ideal candidates for intelligence through compactness and adaptability.*

DIAGRAMMING ICON INTELLIGENCE THROUGH LOGICAL STAGES

In order to achieve a useful and applicable definition for the term “intelligent icon” a three-staged analysis method was designed. This process was illustrated through a flow chart diagram. The branches of the flow diagram either disqualify or advance the example toward what is referred to as “intelligence.” This paper proceeds with a go, no-go logic toward this intelligence capability. This page provides an overview to the entire schema. As a pre-filter to this schematic readers should again consider pictorial, quantitative, relational, and symbolic imagery in general—particularly as it refers to notions of constrained, semi-constrained, and unconstrained (adaptive) patterns.

ICON VS, NON-ICON CONSIDERATIONS

Pictorial and relational classes are composed of only constrained or semi-constrained variants. These classes serve generally as basemaps. This limitation disqualifies these two classes because they are not icons (that is to say that they usually organize things, and are not organized by things).

Both the quantitative and symbolic classes have distinct constrained and unconstrained variants. In each case, the constrained subclass cannot be an icon (e.g. xy coordinate system/a line that organizes page of text). This results in only two subclasses that may advance through our logical checkpoints: quantitative unconstrained (quantigraphs) and symbolic unconstrained (pictographs). These superfluous elements carry their own meaning (context independent). Therefore, they may be placed over any of the constrained or semi-constrained patterns to acquire additional levels of meaning. Aspects of conceptual characteristics respecting icons will be covered in this part of the article.

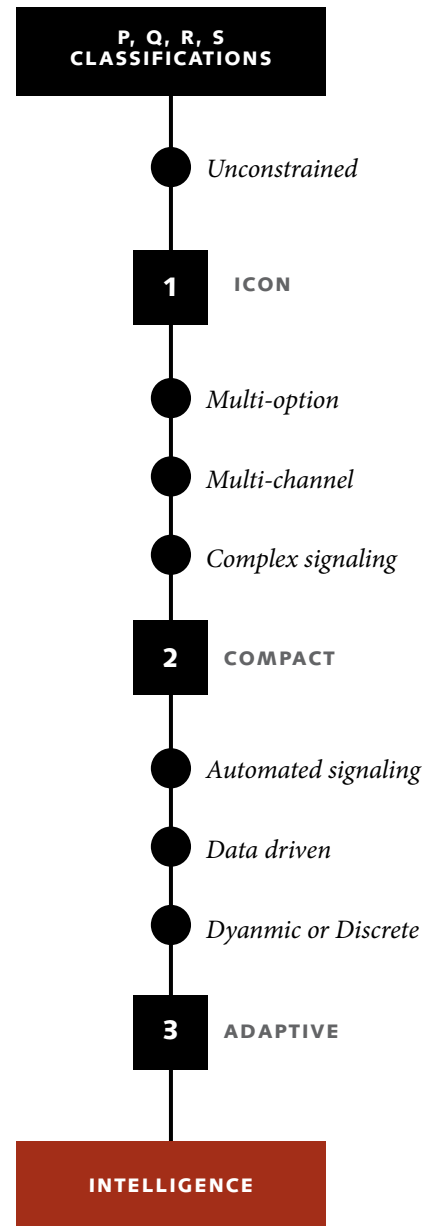


FIGURE 3: Considerations applied to visual representations that determine the nature of icons and intelligent icons. Icons are derived from the primary types (Pictures, Quantities, Relationals, or Symbols); Intelligent Icons are defined through characteristics of sophisticated Compactness and functional Adaptiveness.

MAPPING THE CONSIDERATIONS FROM ICON TOWARD INTELLIGENT ICON

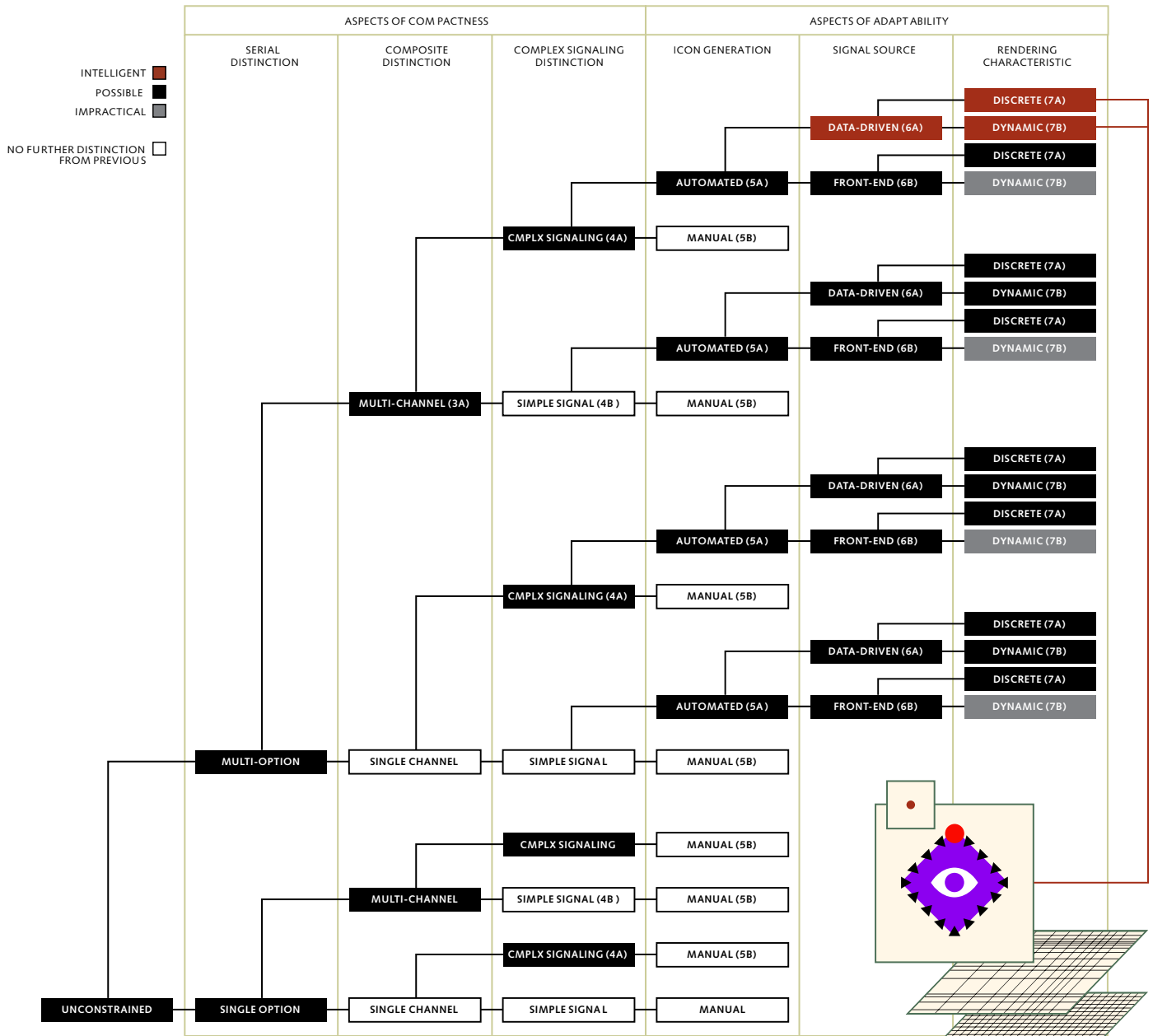
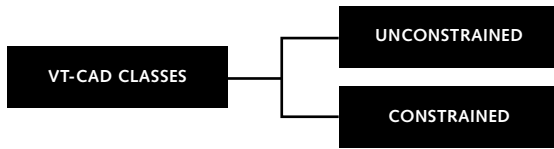


FIGURE 4:
This diagram begins with the logic supporting the definition of an icon: and unconstrained visual device. (This definitively limits the pool of the eight visually representative subclasses from VT-CAD to only the pictographic and quantigraphic variants.) From these two candidates six further distinctions carry the logic from icon to intelligent icon.

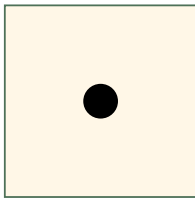
In the lower right hand corner an example of an intelligent icon is depicted (in this case, a healthcare service icon [to be further defined within this paper]). As the device is unconstrained it can be positioned within all the other constrained and semi-constrained arrangements: thus taking an informative device and generating a super-informative context.

1: THE CONCEPTUAL DISTINCTION

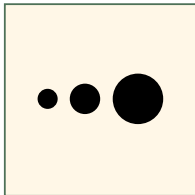


The first level of distinction concerns the nature of iconographic versus non-iconographic visualization. Icons are, by design, unconstrained. They carry meaning “inherently” or through temporary application. They can stand alone or be placed into the context of other patterns. This simple schematic illustrates the first division: two of the eight possible patterns qualify to support icon devices.

UNCONSTRAINED

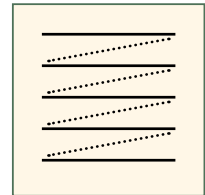
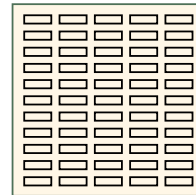
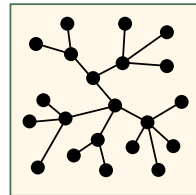
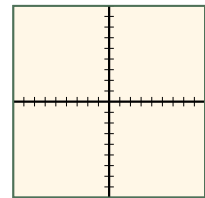
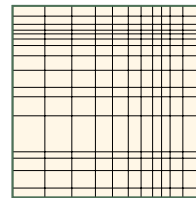
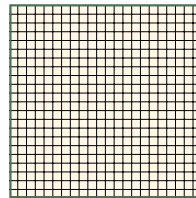


The two unconstrained subclasses: symbolic (above) and quantitative (below)



The remaining six constrained and semi-constrained subclasses: both pictorial variants, the constrained quantitative variant, both relational variants and the constrained symbolic variant (read left to right above and left to right below)

CONSTRAINED AND SEMI-CONSTRAINED



COMPACTNESS VS. NON-COMPACTNESS CONSIDERATIONS

Having extracted our two subclasses (out of the possible eight), the next considerations deal with the notion of compactness. Compactness requires three attributes: multiple options, multiple channels, and complex signaling. These attributes increase the possible number of variables communicated by the icon while minimizing cognitive load and maintaining a consistent real-estate footprint. Compactness vs. non-compactness will be covered in the next installment of this paper.

ADAPTIVE VS. NON-ADAPTIVE CONSIDERATIONS

Intelligent icons are “living” devices. Their composition (based on the attributes mentioned above) is a reflection of the data that supports them. When this link, automated by an electronic database, continually modifies the potential representations of the icon in question then the icon is considered to be adaptive. Adaptability is comprised of three attributes: automated signaling, database-driven, and either a dynamic or discrete rendering characteristic.

These aspects are the chain of considerations that first determine a fair description of the term icon, and then, through deeper considerations determine aspects

of intelligence as applied to icon rendering. Adaptive vs. non-adaptive considerations will be covered in the next installment of this paper.

CONSTRAINED, CONSTRAINING, AND SEMI-CONSTRAINING VS. ADAPTIVE

Constrained and semi-constrained patterns cannot be considered part of the icon family. Each of these patterns is generally contiguous in their design. Conceptually, they can grow infinitely according to their nature. In other words, they are intrinsically not compact. Their non-compactness often forms the ground that becomes the context for the compact, unconstrained devices.

Dimensionally, the two icon subclasses can be considered as dots or dot sets. In contrast, the constrained pictorial variant can be understood as a series of endless points; the semi-constrained pictorial class represents these same points, albeit selectively modified or exaggerated; the constrained relational is a series of cells; the semi-constrained relational, a pattern of links and nodes; the constrained quantitative is composed of projected dimensions; and the last subclass, the constrained symbolic, is represented by a line. It is true that some of these can be distorted iconographically and placed within the context

of others; however; their inherent irregularities and ability to grow infinitely in one or more dimensions prevents them from ultimately achieving true iconographic intelligence.

SOME ASPECTS CONCERNING THE NATURE OF ICONS

Visual devices that possess inherent or applied meaning (and may be placed in whatever context the designer considers informatively valid) are here called unconstrained devices, or icons. These devices are not part of a continuing or contiguous pattern.


A logo is an unconstrained device—placed on a letterhead or building it serves as an identifying mark (the source of the correspondence or the occupant of the building). An image of a cow on a road sign is unconstrained. It warns drivers that cows may be on the road ahead. A question mark, standing alone, may signify information (in answer to enquiry). The logo is a logograph; the simplified cow image is a pictograph; the question mark is an ideograph. *Logographs, pictographs, and ideographs are unconstrained symbols; therefore, they may be considered icons.* Most are qualitative and stand independently.


Some icons are quantitative in nature. We call such icons *quantigraphs*. Their meaning tends to be applied (e.g., through a key) rather than inherently derived. Quantigraphs are generally interdependent: they become most informative through their serial interrelationship. *Quantigraphs are unconstrained quantities and also belong to the icon family, however, as their size may vary depending upon the quantity they convey they may not be inherently compact.*


CULTURAL VS. CONTRIVED KEYS


A symbol may be understood as a three-part construct: only the symbol itself is seen, but there are two “unseen” parts. There is the *signified*, the symbolized thing itself, which is generally not physically present or is otherwise not physically presentable. There is the *signifier*, the symbol itself, which is designed (or visually evolved) in some manner to represent the signified thing. The symbol is therefore the signifier. And, there is a third thing which we refer to as a “*key*.” The key is some associated interpretive entity that allows us to cognate the connection between the symbol (signifier) and the symbolized (signified). These associative interpreters may be *cultural keys* (or natural keys) or they may be *contrived keys*. When symbols are “directly” aligned to that which they represent, such as through a simple pictograph of an easily recognized natural form (e.g., a common seashell) they depend on natural or cultural keys to be deciphered and understood. These symbols have meaning because we are experientially exposed to that which they signify. Evidences also exist that such understandings may possibly be “inherently” psycho-physical—that as humans we may have an instinctual understanding of some symbols: a humanoid skull for example. Either way, these types of symbols may be informed and specialized to the point of becoming proprietary through marketing (contrived experiences); the key remains somewhat natural, however. (Linguists and semioticians may shudder and shake at this generalization, but the point is simply that the user is familiarized to the symbol


ICONS UTILIZING CONTRIVED KEYS

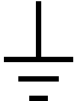
 “Yo” phenogram
King Sejong’s Hangul, 1446

 “Less than”
Attributed to Thomas Harriot, 1631

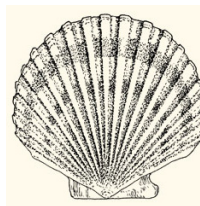
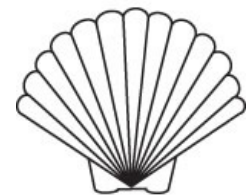
 “Less than or equal to”
Early version used by John Wallis, 1670

 “Less than or equal to”
As used by Pierre Bouguer, 1734

 “Aluminum”
Dalton’s Atomic Symbols, 1803

 “Earth Ground”
Electrical symbols

ICONS UTILIZING CULTURAL KEYS



through the cloud of their experience rather than a contrived guide.) Ramp-up is the time it takes a user to know what a symbol means. Natural keys are associated with rapid ramp-up. Difficulties of specificity are inherent to rapid ramp-up, but the benefits of using commonly understood visual signifiers is otherwise self-evident.

Conversely, those symbols that come to be understood through specialist jargon and specific guides to their interpretation (e.g., military field strategy symbols, chemistry symbols, electronics symbols, contract plumbing, etcetera) take a longer ramp-up time to learn but are correspondingly more specific in meaning. These type of symbols have their associative interpretive keys with one-to-one reference guides. Descriptions are simply attached to the symbol for the purpose of learning its meaning and not attached when the symbols are used in practice. Of particular merit in this respect are sets of symbols that are purposely and functionally “invented” as opposed to organically evolved. Systems of symbols that have an identified origin, originator, and underlying logic are compact and specific by design intent, and this lends them underlying characteristics toward adaptability and iconographic intelligence.

CONCLUSION

These ideas of constrained, semi-constrained, constraining, and semi-constraining patterns vs. adaptive elements establish our first go, no-go division toward icons and icon intelligence. Contiguous patterns are not icons. Single elements may be icons. icons fall under multiple classes: pictograph, ideograph, logograph, and quantigraph. These are all somewhat compact in nature and may be moved over a basemap field to convey contextual meaningfulness. That is their first state, i.e., being an icon. By adding attributes to these icon elements: multi-options with a series, multi-channels within element within that series, and complex signals within that element intelligence emerges. From here another series of attributes can be added: automation and adaptability. These further attributes will be discussed in the next installment of the article.

BIOGRAPHIES

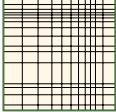
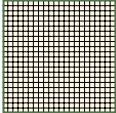

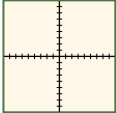
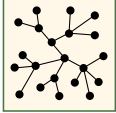
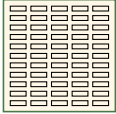
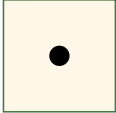
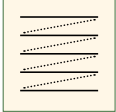
William M. Bevington is the Associate Professor of Information Mapping in the School of Art, Media, and Technology at Parsons The New School for Design, The New School, New York. He is an Information Theorist within the Parsons Institute of Information Mapping, and formerly served as PIIM’s Executive Director. Previously, he was the Chairman of the Communication Design department at Parsons School of Design, served various professorial and instructional roles at his Alma Mater, The Cooper Union for the Advancement of Science and Art. He is an information designer and information theorist specializing in creating tools for the rapid assessment of complex data. His first significant project was the Blackout Procedures Manual for Con Edison in 1983, and the last was a major Geospatial Media Mash-up Tool under U.S. government contract entitled the Geospace and Media Tool (GMT). Mr. Bevington has developed toolsets for transit systems applications, stock trading applications, and health management tools as a principle designer at Spire Integrated Design, New York. He has lectured worldwide, illustrated Graphic Designers Production Handbook, co-authored Working with Graphic Designers and Designing with Type with Jim Craig. He is also the author of Typography: The Principles, A Basic Guide to Using Type published by The Cooper Union.

David Fusilier has previously worked as an information and interaction designer at Parsons Institute of Information Mapping and a typographic designer at the Brooklyn-based Darden Studio. He is a graduate of Parsons The New School for Design, The New School, earning his BFA from the Communication Design and Technology department. Formerly, he pursued a premedical curriculum at Louisiana State University, complimented by jobs working as both a medical records clerk at the Baton Rouge Clinic and a volunteer in the endoscopy department of Our Lady of the Lake Hospital.

ENDNOTE

The table is based on the eight structural classes that support informative visualization as presented in: William M. Bevington, "PIIMPAPER 01, Part One: A Visualization-based Taxonomy for Information Representation: Introduction and Overview" (New York: Parsons Institute for Information Mapping, 2007).

GRID PATTERNS AND THEIR UTILITY FOR INTERRELATABILITY

CLASS AND VARIANT	CLASS AND VARIANT
 <p>PICTORIAL <i>Semi-constrained/ Semi-constraining</i></p>	<p><i>distorted maps, illustrations</i></p> <p><i>satellite imagery, photographs,</i></p>
 <p>PICTORIAL <i>Constrained/ Constraining</i></p>	
 <p>QUANTITATIVE <i>Adaptive</i></p>	<p><i>symbols scaled one to another to reflect quantities</i></p> <p><i>bar charts, line graphs stack graphs</i></p>
 <p>QUANTITATIVE <i>Constrained/ Constraining</i></p>	
 <p>RELATIONAL <i>Semi-constrained/ Semi-constraining</i></p>	<p><i>node-and-link diagrams, networks</i></p> <p><i>spreadsheets, tree maps, tables</i></p>
 <p>RELATIONAL <i>Constrained/ Constraining</i></p>	
 <p>SYMBOLIC <i>Adaptive</i></p>	<p><i>ideographs, pictographs</i></p> <p><i>letters, glyphs, Morse code, braille, binary code</i></p>
 <p>SYMBOLIC <i>Constrained/ Constraining</i></p>	