Abstract

The article proposes a five-part schema for analysing the design process in constructing visual representations. Its purpose is to highlight the multiple ways in which the objectives of a design influence the final form: pictorial pragmatism, driven by the objectives, is taken to be the dominant force in determining that form. The schema is valuable when considering the relationship between aspects of the reality to be modelled and those of the designed representation. While accepting that a useful distinction is captured by the terms realistic and metaphorical, an argument is developed that this distinction cannot be strictly held. The notion of expressivity is examined and the pragmatic model of depiction is further explored, in which expressivity is shown to be often increased by mismatches between what is seen and its graphical representation. The aims of the article are: to question simplistic models of depiction; to provide a simple but robust framework for thinking about depiction and related forms of designing; and to act as a guide in the advanced education of designers, in particular making them aware of the extent of the choices open to them.

Stephen Boyd Davis runs the Lansdown Centre for Electronic Arts, a University Research Centre at Middlesex University dedicated to interdisciplinary work in digital media. He shares the Centre's commitment to continuous innovation—but also sets new media practices in wider historical contexts. His aim has always been to inquire radically into the possibilities of media and technologies, exploiting their special properties to the full. In addition to running the Research Centre and teaching, Stephen supervises PhD students who are developing new creative applications for technology. A Fellow of the Royal Society of Arts, he is a member of the Peer Review College of the UK Arts and Humanities Research Council, a referee on the Scientific Committee of the Design Research Society and on the management committee of the Computer Arts Society.

Stephen Boyd Davis

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A Schema for

Introduction

The article proposes a five-part schema of the design process in constructing visual representations. Rather than emphasizing the relationship of pictures to what they depict, emphasis is placed instead on the opportunities for *transformation*, at a number of conceptually distinct phases, between the observation (or imagining) of an object or scene and its final representation in a graphic. Thinking of depiction as some kind of matching to what we see is a widespread misconception. Instead we should think of depiction operationally and pragmatically.

Although the primary example used here is the familiar one of picturing a waste receptacle or trash-can which allows the computer-user to delete files, the schema is argued in relation to other forms of depiction created for other purposes and in different contexts, in order to demonstrate its usefulness and applicability. The schema is meant to be useful to the designer as well as the theorist, in particular by drawing attention to the freedom and range of choices available, and clarifying the purposes they can serve. Initially a simple five-step model of visual representation is set out, which is then refined through discussion of the issues raised.

Background

The term *schema* is used here in its general sense of a structured representation in the form of a diagram or plan. The schema proposed is intended to make it easier for designers and theorists, to think about the purposes of depiction and how those purposes influence—or should influence—the form of the picture.

In the author's experience, working with postgraduate students of design and with professional designers, there is a common tendency to think differently about two classes of graphic representation: on the one hand, figurative graphics (referred to here simply as *pictures*) and, on the other more obviously 'designed' representations such as diagrams. Picture-making has even been called *thoughtless imitation* when compared with thoughtful diagram design (Kazmierczak, 2001, p.179). When people learn to make pictures, there is a strong inclination to over-emphasize the relationship of the depiction to what it depicts and correspondingly to ignore or underestimate the relationship of the depiction to the purposes it serves. As a result, many opportunities for selection and transformation of the original object or scene, in order to serve the objectives of the representation, are ignored.

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Depiction

Part of the problem is that there is a lingering hope that pictures and other designs can somehow completely capture what they represent. Whether in figurative picture-making or in information design, a belief emerges that: representations can be complete; representations can be unambiguous; and that representations match something in the world. By contrast, **the pragmatic model offered here is one based,** to borrow Gombrich's phrase (1977, p.248), **on the dominance of *making* over *matching*.** The term *pragmatism* is used here to mean a focus on results—a concern with what a picture does to and for the user or viewer and with how the characteristics of depiction can be understood in those terms.

Conceiving representations as designed pragmatically, to inform and affect the user, their truth to something external becomes less vital than their effectiveness. This is not, of course, a cynical invitation to lie with graphics, but rather an acknowledgement that representations can not be complete, can not be unambiguous, that in sum, they are just as they are called—representations. This inadequacy of depiction might be conceived as rather depressing, but it will be argued here that the way in which representations fall short of matching what they represent, far from being a cause for regret, is a vital part of their expressivity. In fact this is an old idea. Descartes (1954. P.245) remarked: "very often the perfection of an image depends on its not resembling the object as much as it might." Rather than simply repeat this observation, the aim here is to construct a schema for the component processes by which pictures relate to what they depict and to the objectives they serve, in order to get a better grasp of what the picture-maker does.

An outline schema of visual representation

Consider the subject matter of a picture, which will be referred to here as the model, *M*. This model may be a directly observable object or scene in the world or one that is imagined based on recollection of how things look. The model *M* is to be represented in picture *P*. This picture *P* might be a picture of any kind. In principle, the schema offered here is applicable to all pictures, even to film and other dynamic images.

M, the model, itself represents something, an idea, *I*. This is most obviously the case where ostensive subject matter has a metaphorical or symbolic meaning so that, for example, a dove represents peace or a trash-can stands for the concept of deletion. But even a more literal picture, such as an illustration to enable a part in a furniture kit to be identified, is the carrier of an idea. While I is a generalized notion, *M* is a particular instantiation of that notion in an example. Some pictures are more particular than others: a road sign, a desktop icon or a way-finding symbol generalizes far more than a photograph, for example. But the need to choose some particular instance of the idea is always there to a certain extent.

The stages of representation from idea to picture can be set out in the form:

$$I \rightarrow M \rightarrow P$$

In the case of the familiar trashcan in the computer interface, the three phases can be laid out as in Table 1, where a general notion of a trash-can is instantiated in some particular model and this model is then rendered as a visible picture.

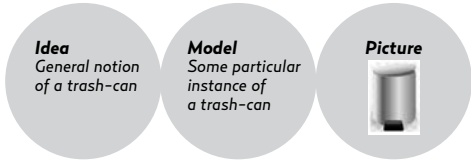


Table 1 A general notion of an object that has a particular instantiation that is pictured.
(The trash-can picture is a public domain image by Andy Fitzsimon taken from Wikipedia, 4 March 2007.)

However, the idea, *I*, is selected to serve some objective, or set of objectives, *O*, requiring us to add another phase:

$$O \rightarrow I \rightarrow M \rightarrow P$$

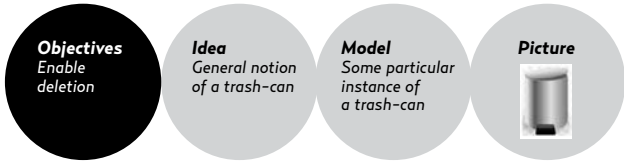


Table 2 All pictures serve purposes. The idea serves to further the objectives of the picture.

While Table 2 now shows the objectives, *O*, as motivating the idea, *I*, the schema needs still further augmentation, this time at the other 'end' of the process. We need to represent the fact that another representational process takes place between the model M and the picture *P*.

This is because the model *M* is pre-pictorial and probably three-dimensional, but the picture *P* is flat. Here it is useful, to some extent, to borrow from the pipeline metaphor of synthetic computer graphics (Foley et al 1995, p.334-5, 806-9), in which it is normal to separate conceptually two sets of decisions in the making of a picture: one involves the geometry and other attributes of the model *M*—whatever is to be depicted—while the other relates to the visualization of the model necessary to its

display, including such factors as point of view, framing and so forth, denoted here as *V*. Each is of course essential. There cannot be a viewpoint onto nothing—the model is essential. And the model is useless for the purposes of depiction unless it is viewed.

The stages can now be redrawn as:

$$O \rightarrow I \rightarrow M \rightarrow \mathbf{V} \rightarrow P$$

For the trashcan example, the five phases are shown in Table 3. This crudely represents how the objectives, *O*, inform the selection of an idea, *I*, which is instantiated in some particular model, *M*. This in turn is viewed, *V*, in a particular way and finally pictured, *P*, using certain media, rendering techniques and so forth.

Such a simple schema does not pretend to capture the subtleties of real depiction. For example, where exactly would one place the choosing of a projection system, such as a choice between three-point and axonometric perspective? Is this best accounted for as an aspect of the viewpoint or of the final picturing process? Provided the coarseness of the diagram is borne in mind, it may nevertheless be useful.

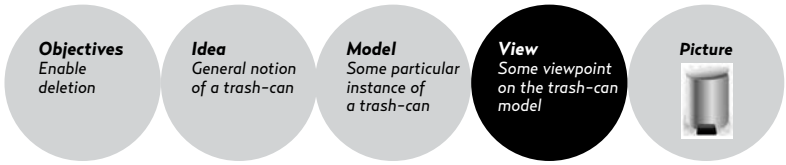


Table 3 The model, instance of the idea, cannot be depicted without a point of view. The selection of viewpoint is a vital aspect of the relation between the model and the picture.

Other simplifications in the diagram include the fact that it shows each of the stages as singular, whereas in practice many stages will have multiple aspects: for example, the objectives, as already noted, are likely to be many for a single picture. Similarly a single model may yield innumerable views and pictures and so forth. Another important point is that the process shown in Table 3 appears to be linear and uni-directional. As discussed later, such an impression would be misleading.

So far, the left-to-right arrows in the sequence have been left undefined. They might be taken to suggest a logical implication or inevitability, but that is not at all what is intended here. Every one of the conceptually distinct phases is an opportunity for intervention. Macdonald-Ross and Waller suggested in 1974 the idea of the designer as transformer, who takes another person's knowledge or message and finds the means to convey it to the intended audience (Macdonald-Ross and Waller

2000). Similarly, the argument here is that, even in the case of pictures, **each transition should be conceived as a transformation, an opportunity for interpretation and expression, not as a mechanical, inevitable mapping.** In particular, the transformations from the model to the view and to the picture require examination.

Model to view to picture: processes of transformation

While it is obvious that diagrams need not visually resemble anything which they represent, it is equally clear that for pictures—by definition—some resemblance is involved. There have been many discussions of just how these two graphic modes may be assimilated or differentiated, on a variety of grounds (Norman, 2000; Kazmierczak, 2001). In his *Schema for a Graphic Language* (1987, p.204), Twyman uses a dotted rather than a solid line between the categories *pictorial and schematic* to suggest some continuity between the two. Engelhardt's *Language of Graphics* (2002) usefully integrates terminologies and concepts from many graphic modes including both diagramming and depicting (but does not deal with the transformations of view and picture described here).

In grappling with these problems, the term *automorphism,* as introduced by Currie (1995, p.97), is useful: it names the match between a property of the thing to be represented and a corresponding property in the representation. Normally in a picture, *a* being to the left of *b* maps the fact that *A* is to the left of *B* in the scene. Of course, automorphism is not an absolute: degrees of automorphism are common, as when the widths of roads on a map approximate to, but do not arithmetically scale to, the widths of the roads represented. In the London Underground map, there is some automorphism between locations in the city and locations on the map, but the colors of the lines are arbitrary—there is nothing red about the Central line itself.

Some degree of visual automorphism is definitional for all pictures, and if a picture could be a perfect representation of a scene then it would be completely automorphic. However, we shall see that no such perfect representation is possible. There are two fundamental difficulties. The first is deciding what constitutes the *depingendum*—the thing to be depicted (this term has been adopted in order to avoid the too-specific implications of words like *object or scene,* and clumsy repetition of lengthy phrases like 'the thing to be depicted'). The other difficulty is in deciding on the relation between this depingendum and the depiction. We need to establish the limits of what can be done, and by this means to work towards a useful concept of expressivity—the ability of a representation to communicate effectively.

Pinning down the depingendum. It is often assumed that what is 'out there' to be captured is uncontroversial but, even in a strictly practical way, it is easy to demonstrate that the status of the depingendum is problematic, simply because it is

not 'out there': it is inextricably involved with active, constructive perception. It is often pointed out that no picture is neutral towards its subject, as for example Kress and van Leeuwen do when they say, 'Pictorial structures do not simply reproduce the structure of reality. On the contrary, they *produce* images of reality' (1996, p.45). But the additional point here is that, even prior to picturemaking, **perception itself is a constructive, selective process.** It has frequently been suggested that a picture can imitate reality by presenting the same stimulus to the eye as the scene itself (something that the special case of *trompe l'oeil* images really attempt to do). Though he subsequently renounced it, Gibson (1954) originally offered just such an idea of a 'faithful picture': "A delimited surface is so processed that it yields a sheaf of light-rays to a given point which is the same as would be the sheaf of rays from the original scene to a given point."

A fatal problem with this conception, as Gibson later realized, is that perception *is not* the sum of a series of flat pictures, but the result of an active negotiation with the world in depth. Whereas it used to be thought that, in natural vision, the entire visual field is in focus at once—and the history of pictures is dominated by images which are entirely focused both in depth and breadth—it is now known that this is far from the case. For one thing, the eyeball itself changes shape as it surveys the scene, in order to alter the focusing distance (accommodation). And in addition, only that portion of the scene which is opposite the fovea is clearly resolved, so through saccadic movements of the eyeball the fovea is exposed to different parts of the scene. So, both in depth and across the scene, it is impossible for all parts of the scene to be equally resolved. However, there is a profound complication to this simple truth. Since we are not generally conscious of the eye's altering focus (and never of the saccadic movements) it could be argued that a representation which is in focus across its whole surface is true to our *experience*. We have therefore *two valid claims* to realism. Similar mismatches of what have been called *logical* and *psychological* truth also arise in relation to perspective geometry and scale, as noted in very different contexts by Klee (1968, p.41) and Gregory (1977, p.174).

This problem of truth-value arises even in the case of photographs, often still regarded as the benchmark of perfect representation (*figure 1*). Prince (1996:28) notes that C.S. Peirce conceived photographs as indexical traces that 'correspond point by point to nature.' Barthes considered them as operating without a code (Barthes, 1977, p.17). Such a conception underpins the views of film theorists like Bazin (1967, p.46) who often suggest that realism has an unproblematic relation to the scene: we know what scenes look like and film should look the same. As indicated above, the disturbing but exciting fact is that we *don't* know what scenes look like—so we have no way of making pictures, or even films, look the same. Even photographs themselves must be designed—through the selection of lens, aperture, film stock, mechanical form of the camera and so forth—to favor one of several competing truths.

Figure 1 The apparent truth-value of photography is misleading.

Why does any of this matter? The key point is that we are constrained and at the same time liberated, by the impossibility of making a perfect picture, even when using a camera. The emphasis must instead be on pragmatics, on pictures which serve the objectives for which they are made, not on any supposed truth to an objective original. This is largely at odds with the way we are taught to make pictures, where achieving some 'match' between the scene and the picture is normally considered the primary goal. Novice designers are particularly prone to imitating aspects of the real world without considering whether or not this enhances the effectiveness of the design. Visual characteristics then appear in the representation on the grounds that this is the way the world looks, not on the grounds of fit with the objectives.

(Part of an artwork by Andrew Kearney at Middlesex University, London, UK. Used with permission.)

Pictures as representations —towards a definition of expressivity

In the transformations from model to view and to picture, distortion, attenuation and omission are all common. A particularly interesting case is that of what might be termed *illicit marks*—marks with no corresponding presence in the scene. Probably the commonest is the drawn outline. So ubiquitous is it in pictures that we can easily forget it has no basis in the observed world. Marr's model of vision (1982, p.37) proposed that mental constructs equivalent to outlines are a primary means of segmenting the scene at a very basic level, but this does not alter the fact that the lines are post-optical: they are not present in the scene. Outline in a picture stands for an aspect of the world after it has been perceived, after the scene has been processed by the visual system. Instead of imitating the external stimulus of the scene—the optical depingendum—it evokes the cognized, meaningful *experience* of looking at a scene, rather as we saw in relation to uniform focus.

Outline is a significant example of the ways in which the weaknesses of representational technologies are turned to strengths. For example, in some cartoon drawings, a shape outlined in black can be additionally separated from the background by a white outline (Kurlander, Skelly and Salesin 1996, p.229). It is also used in graphical user interfaces to make the cursor 'float' over all other displayed elements. These are informational advantages. Richards, in a celebration of outline from Leonardo to modern technical illustration (Richard, 2006, p.103), highlights its superiority over purely tonal rendering when the structure of complex objects must be conveyed. Through suitable use of line, the image can also be expressive in other ways. Often lines are inscribed onto the surfaces of objects in drawings, which tell us what it would be like to trace one's finger across the surface of the object rather than merely to see it. It is not true to suggest that pictures are limited to what we can see: the picture-maker is entirely free to embed tactile and other knowledge into the visual representation, and arguably, the finest picture-makers do just that.

Importantly, picture-makers do not adopt a rigorous logic in their use of illicit marks. This is another aspect of pragmatism: such marks are usually combined with purer optical data in an *ad hoc* way, which may be driven as much by the ongoing solution of pictorial problems as by any preconceived system. Wollheim refers to the picture-maker building up *analogies* between the medium and the object of representation, seeking an 'ever more intimate rapport between the two experiences' (Wollheim, 1980, p.224), and Podro remarks how 'line connects shape to movement as they can be connected only in drawing. Shape and movement become projected onto each other, so that while making recognition more replete the image takes on a structure which *has no equivalent outside depiction*.' (Podro, 1998, p.9 emphasis added).

Figure 2 Pragmatic picturemaking. The picture-maker's marks operate in a multitude of relations to the scene. (Page from an early nineteenth-century sketchbook, detail. Author's collection.)

In Figure 2, **marks have many functions in a pragmatic evocation of experience.** They operate in a multitude of relations to the scene: now delineating the contour of an object, now creating shadow; indicating a surface retreating in depth; caressing the cylindrical shape of the foreground logs; selecting telling details such as the keyhole, hinges and nails of the barn; making a dramatic contrast between the angled stakes and the rectilinear barn wall; evoking the exuberant wildness of the creeping plants in full leaf straggling over the building. *V* and *P* are therefore representational transformations, not transmissions. They make it possible for the picture-maker to 'tell' about the scene graphically not simply to 'show' it. To quote Richards on the art of technical illustration: "The question is not: is this what the component looks like? Rather it is: **does this collection of graphic marks provide the viewer with the appropriate information to 'read' the illustration?"** (Richards, 2006, p.103).

Expressivity and information

It is time to be more exact about the nature of expressivity in pictorial representation. Initially the discussion will concentrate on those aspects of depiction that are primarily informational. Subsequently, the affective aspects of expressivity will be tackled.

In the context of information visualization, Mackinlay (1986, p.114-6) proposes a strict test of expressivity, that representations must 'encode all the facts in the set and encode only the facts in the set.' This definition harks back to the idea of perfect and complete representation which was rejected above. It might be characterized in Table 4, where facts in the source are mapped to features in the representation, each with its direct counterpart.

It is reasonable to say, as Tufte (1983, p.55-77) and Wainer (1997, p.22-25) do, that for instance, three-dimensional visual representations should not be made when only two dimensions of data are available. In this limited sense, it is quite acceptable that Mackinlay does not want a representation to introduce unwarranted additions to the source facts. At heart, however, Mackinlay's expressivity is defined on the basis that 'the facts' can be established unequivocally; that all that ends up in the representation was found within the facts; and by implication, that the design should act as a channel transmitting these pre-existent facts to the viewer. It is a quite widespread supposition that source data has immanent structure, and that design can or should transmit this straightforwardly. For example, Card et al (1999, p,10-11) present a model of data visualization described in a linear fashion with no apparent place for the design process to alter the conceptualization of the data. Designers sometimes subscribe to a similar view. The designer of a three-dimensional timeline claims, "The information being visualized has its own intrinsic multi-dimensional semantic structure" (Kullberg, 1995, p.22 emphasis added). This view of information sees representation as transparent to content, and content as self-evident in the world. By contrast, March and

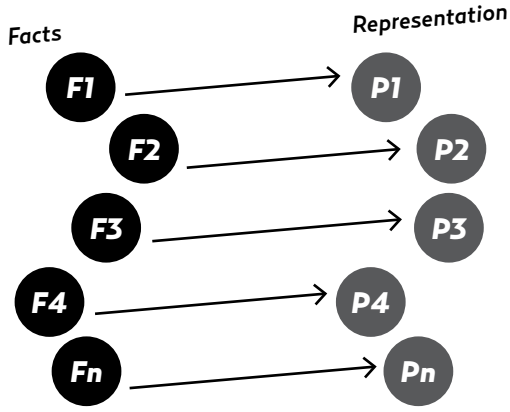


Table 4 A model of representation based on Mackinlay's definition of expressivity. Facts in the source are mapped in the representation.

Steadman (1971, p.29) emphasise the multiple patterns accessible in a data set—and the importance of questioning the pattern that most readily comes to the fore—while Kazmierczak (2003, p.46) passionately argues that "Data per se is meaningless. It merely is a collection of symbols/interfaces, which have been acquired as a result of an inquiry. To answer specific queries and become meaningful information, data must be organised," so that the design does not act as a transparent channel for the data, it makes the data into information. This takes still further Macdonald-Ross and Waller's concept of the transformer cited above.

Not surprisingly, the lack of a perfect fit between the facts and the representation is a source of disappointment to some. In the well-named essay "The Problem of Representing Knowledge" (1972) the same Macdonald-Ross earlier regretted the ambiguities and slippage that visual representations of knowledge bring with them. Nardi and Zarmer (1993) attacked metaphorical representations in the interface on the grounds of their ambiguity and lack of precision, but failed to notice that all representations are more or less subject to these 'failings'—because they are representations.

A preferable overall model of visual representation is presented in Table 5. **If the 'facts in the set' are considered to be the ideas for which the model stands, then a picture can represent more than the set of facts, for instance by having both a simple pictorial and a metaphorical relation to its subject.** A picture also adds to the source facts through reference to common knowledge, including knowledge of other pictures. And a fact in the set, such as the curvature of a surface, may, as we have seen, be transformed into an analogous mark in the representation, instead of being represented directly. In addition, any picture also presents *less* than the facts, since no representation can show all aspects of the model, particularly when a three-dimensional world must be mapped to the plane. Mackinlay's definition of expressivity – the facts in the set and only the facts in the set – is clearly wrong.

The alternative model favored here is a view of design as a form of

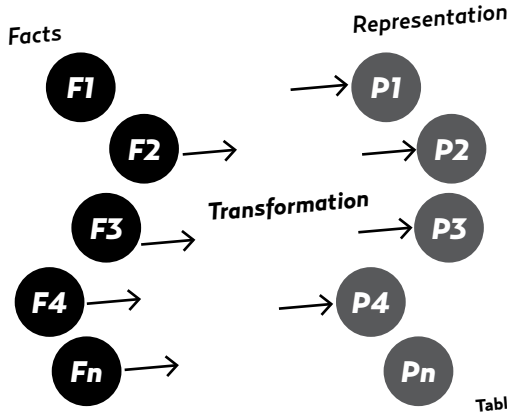


Table 5 A modified model of representation based on the ideas presented in this article. Selective observations from the source pass through a process of transformation into the representation, which will usually both fall short of *and* exceed the mere data.

rhetoric (Poggenpohl, 1998) which places the transformation from content into form in a setting of human-human purposive communication. It is design as described by design semantics, in which 'making sense of things' (Krippendorff 1989) really is considered as *making,* not matching something which exists and awaits expression. **Pictures are created through a series of transformative interventions, just as diagrams or other graphics which are more obviously 'designed'.**

1. Expressivity refined: information and affect

So much for informational expressivity. However, a vital aspect of communication, in addition to the conveying of information, is *affect*. Here this is taken to include anything which alters the viewer's relationship to the depicted.
It is not concerned only with the emotional aspects, as discussed in relation to design for example by Norman (2004). While *informational expressivity* denotes how much the user comes to know about the depicted scene, *affective expressivity* denotes any changes to the relation between the scene and the user. Though the two aspects are often closely intermingled, it is useful, initially at least, to tease them apart. In each case the location in the schema will be indicated.

Consider the case of selecting a point of view (*V*) on an object, initially in relation to informational expressivity. Some views are more significant than others, probably because they differentiate the object with greater efficiency (Bruce, Green and Georgeson, 1996, p.224)—they are preferable in terms of their ability to convey information. Particularly for icons and similar graphics, what is generally needed is a canonical view, providing simple object identity without attention to momentary appearances (Hagen, 1980, p.13). To offer an extreme case, if the trashcan discussed here were pictured as in Figure 3, it would be a poor representation, inexpressive in informational terms. Holmes (2001, p.140) tells how, in his practical design experience, he tries "to find the most representative view of an object." For instance "a true side-on view, or profile, of a pair of spectacles does not remind you of spectacles, it's just a capital letter J on its side." The inexpressivity of some views has been exploited in visual riddles such as Figure 4.

Figure 3 An inexpressive view of the trashcan. Some views are more expressive than others.

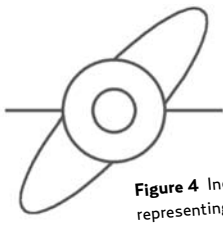


Figure 4 Inexpressive views as a source of visual humor, a traditional visual riddle for children, representing a man in a sombrero paddling a canoe.

Blanz, Tarr and Bülthoff (1999) have measured the angles at which subjects elect to view a three-dimensional model and produced a persuasive illustration of the clustering around the particular angles that provide canonical views (*figure 5*). All are views in which the defining characteristics—the overall shape, the spout, the handle and the knob of the lid—are visible. Almost every viewpoint chosen is above the horizontal. Recalling the trashcans depicted in the history of the desktop metaphor, each has either been viewed in simple elevation (as in the early Macintosh operating systems) or from slightly above.

But in addition to the informational expressivity of such a view, is there an additional, affective, aspect to this choice of viewpoint? Users should feel in control of the systems they use—this has long been one of the claimed benefits of well chosen interface metaphors (Carroll and Thomas 1982, p. 112), and to look down on an object is to feel empowered in relation to it. The downward view on the trashcan fulfils this affective requirement as well as the informational need.

If we turn to the rendering of a picture (*P*), the drop-shadows 'cast' by interface widgets in many operating systems perhaps serve some slight informational purpose in enabling the user to more easily locate the boundaries of discrete screen segments, but they also make the objects seem 'more real' in an affective sense. Their arrival in the interface seems to have been contemporary with a particular style of book decoration by the publishers Dorling Kindersley, which used a similar device to make objects on the page seem more object-like and less like traditional book illustrations. It is a device that conveys almost no information but makes users feel different about what they are looking at.

While, conceptually, information and affect deserve separate consideration, in pictorial practice, as the examples given already suggest, they often work in collaboration.

Film demonstrates remarkably how informational and affective aspects can become inextricably bound up in a single device. A close-up (*V*) allows us to see the nuances of a character's expressions (it adds information) but is also affective—it forces a closeness that produces effects similar to being near an actual person (Reeves and Nass, 1998). Similarly, moving the focal plane to alter which part of a scene in depth

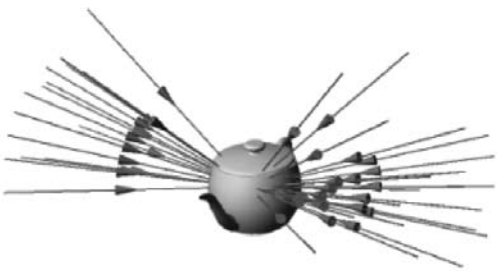


Figure 5 The clustering around a limited set of viewpoints, chosen by experimental subjects, onto a three-dimensional object. These viewpoints favor canonical views. (Blanz, Tarr and Bülthoff, 1999. Reproduced with permission.)

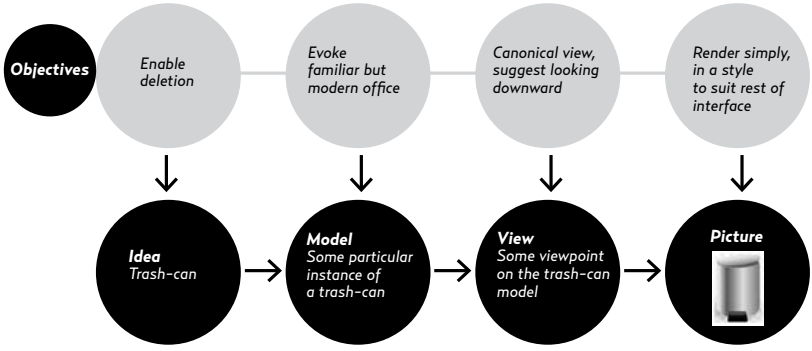
is in focus (*P*) is informational, since it allows something else in the scene to be more clearly observed, but it also has a strong effect on the viewer-subject relationship—it effectively compels the viewer to relate to a particular part of the depiction.

Angle of shot (*V*) is yet another technique which combines informational and affective expressivity. For example a view upwards to a person in a high window may be followed by a view through a window down into the street: the spatial relation between them is constructed by the viewer on the basis of the coherence of these angles. Shot angle here is used an informational device. But, in addition, shot angle has a relation to the film-viewer: it is this that causes an upward view of a character to imbue that character with authority. This is the affective aspect. As Harrington puts it (1973, p.77) the filmmaker "tells the viewer how to feel about a character or an action by a shot angle." This use of viewpoint and other aspects of the transformation to "tell the view how to feel" is fundamental to the effective aspect in all classes of depiction. **Every aspect of the depiction is influenced by the objectives.**

Refining the schema

Returning to Table 3, some weaknesses can now be identified in the draft schema. It was noted earlier that there is an implication of linearity. It might seem that the objectives *O* influence the selection of the idea I, but no other aspect. Nothing could be further from the truth: in fact, as has been shown, they influence every representational transformation.

In Table 6, the schema is restructured to indicate this. In the case of the example given, the trash-can is chosen to facilitate deletion of files; a particular instance of this idea is chosen to evoke a familiar but modern office; the instance is viewed from a canonical viewpoint, which also happens to be a downward view, suiting



▲**Table 6** Reconstructing the draft schema allows the influence of the objectives on every aspect to be identified.

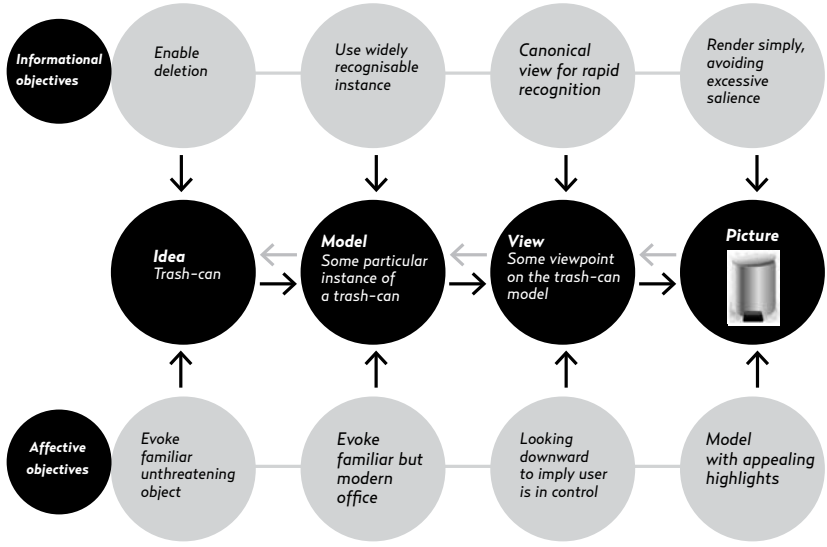
►**Table 7** Finally the schema is restructured so that the role of both information and affective objectives can be identified. In addition, the possibility of 'reverse flow' is indicated, for those cases where considerations concerning the 'output' alter decisions about the 'input.'

the need to suggest that the user is in control; and finally the image is rendered in a simple, unadorned way, one that will sit well with the other elements of the interface.

In the final version (*table 7*) the informational and affective objectives have been separated, not—as already indicated—because they really operate independently, but simply to make clear that both kinds of objectives potentially act on every transformation.

In Table 7, another final weakness of the original ***O → I → M → V → P*** characterization has also been addressed. **In the pragmatic business of depiction, the flow is not always one way. Frequently for example the model *M* is contrived in order to produce the desired picture *P*, so the demands of the picture propagate back to the characteristics of the model.** In the early days of linear perspective, Uccello, in his Battle of San Romano (c1450), contrived particular subject matter—and placed it in somewhat improbable positions—so as to provide plenty of orthogonals projecting dramatically at the point of convergence in the center of the painting. An eighteenth-century painter might order everything in a picture around the S-shaped line of beauty—again working back from the composition to the contents. The filmmaker who wants a low-angle shot, up to the face of a powerful character, will position the character high up in the scene, so 'necessitating' an upward view. Even the humble trash-can may show traces of this 'reverse engineering': once it is decided that the icon will appear low down on the screen, this is probably a third factor in deciding that the downward view onto the object is the most appropriate. Having a trash-can on a desktop may be strange, but at least the point of view is roughly the right one.

To reflect these ways in which objectives may propagate 'backwards' through the representational phases, additional reverse arrows now flow upward through the schema.



The schema applied

Using the schema we can begin to anatomize the transformations employed in the design of another icon. The trash can was a simple icon in which an object stood for an action, but often it is necessary to combine more than one element to suggest a more specific meaning. In Table 8 an icon is presented where two objects are juxtaposed, to represent the action of saving data to long-term storage. One element of the idea *I* is in some ways a fairly literal depiction of the storage medium itself: a disk. The other element is, like the trashcan, an object that stands for an action, a pencil to picture the act of writing. It exploits the metaphor of writing, since no actual pencil is involved in storing data to the disk. Because pencil marks are easily erased it has the advantage of suggesting a recording operation that can later be undone. These are all informational benefits.

What, in terms of information, would be lost by using either element alone? Clearly the disk alone suffers from the ambiguity that it might denote any of a range of disk operations. The pencil alone might be a tool for drawing or for making annotations. Together, the meaning is more clear. **The combination of a literal and a metaphorical element seems quite effective,** though it raises an interesting problem of viewpoint, dealt with below.

In affective terms, the comfortable familiarity of the pencil, the writing tool of childhood, can be thought of as tempering the relative 'foreignness' of the digital technology represented by the disk.

An idea having been chosen, particular models *M* for each element are required. The storage medium appears as a 3.5-inch floppy disk, perhaps because it is the most recognizable instance of this class of objects, even though the icon also denotes writing to other storage media.

The yellow pencil in itself is a rich sign. Approximately three-quarters of all the pencils sold in the US are painted yellow. It has been suggested that the Viennese Hardtmuth Company in the 1890s adopted yellow for its finest pencil to connote the Oriental source of its graphite, since this was claimed to be the best in the world. The color has been described as having become, by the mid-twentieth century, a sign of pencilness (Petroski, 1990, p.163). So the yellow pencil is in itself a canonical instance, both iconic in informational terms and comfortably familiar in its affective aspect.

The idea instantiated as a particular model must be viewed *V* and, when using multiple elements, this also means the elements must be composed as a visual whole. In this case a tricky problem arises from the literal/metaphorical mix. It is necessary to avoid the pencil seeming to write on the label of the floppy disk: this could be misleading. So the pencil seems to write, if anywhere, on the part of the disk

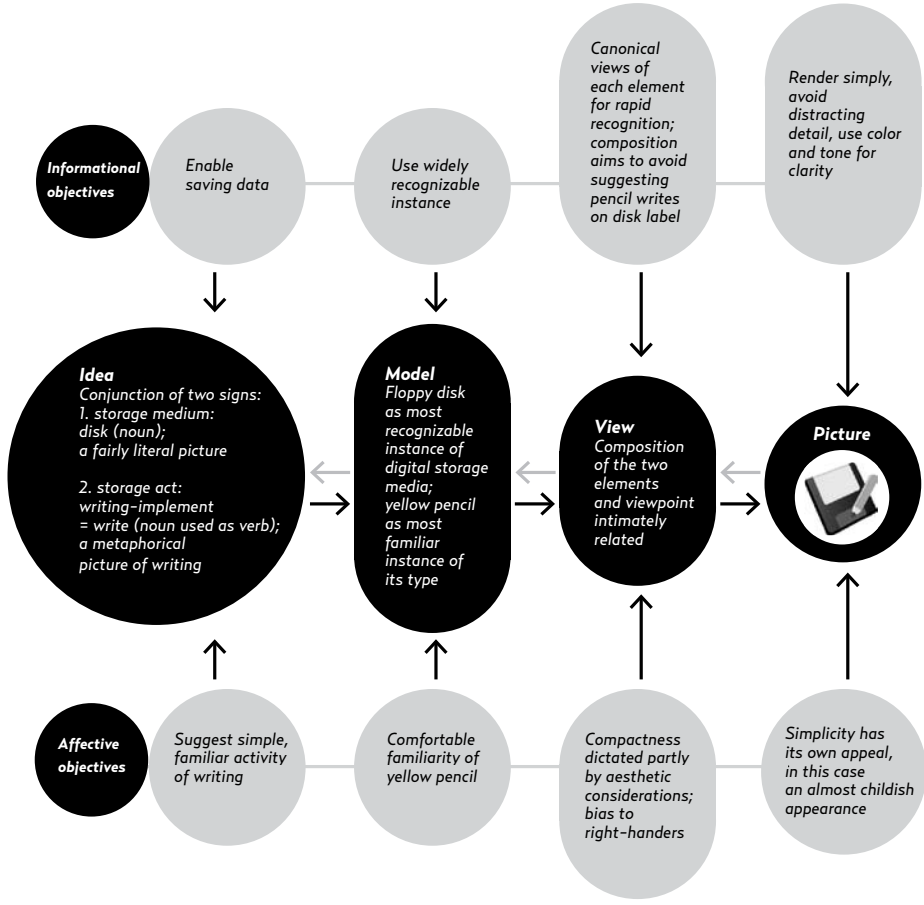


Table 8 From the *iSimple System Icons* set by Dirceu Veiga, May 2006. (Downloaded under GPL licence from Wikimedia May 2007.)

where the read-write head of the disk-drive will operate. There are of course also a host of aesthetic considerations, including the need for the entire icon to be reasonably compact. The pencil depicted is therefore a short one, another example of the backwards propagation of objectives, in this case from the viewpoint to the model. Perhaps the shortness also reinforces the sense of a comfortable everyday household object, rather than a brand-new artist's pencil.

An important issue in terms of affect, is that the composition is laterally skewed: the two elements would only be used in these positions by a right-handed person. In affective terms therefore the comfortable familiarity that the composition evokes in the right-handed majority of users is presumably as irritating to left-handers as the dextral bias of objects in the physical world.

Finally in the rendering of the view as a picture *P*, in informational terms the color of the pencil is an advantage in differentiating it clearly through both tone and hue, while in affective terms it makes a pleasing splash of color on an otherwise monochrome object. As before, a modest style of rendering is chosen: it has a simplicity that is almost childlike, a characteristic of this icon set as a whole.

Summary conclusion

The schema as finally presented is grounded in three key issues discussed above: the impossibility of making perfect representations and the inevitability of mismatch between the scene and its picture; the complex nature of expressivity arising from this mismatch; and the richness of the resulting transformational opportunities available to the designer or picture-maker.

Picture-making has been conceived here as making an artifact that in some way (or ways) makes equivalences for selected aspects of human experience—not as matching anything neutrally existent in the world. Viewing depiction in this way, the designer is empowered. Reconceptualizing depiction in terms of expressivity, the focus is shifted from the relationship between the depiction and what it depicts, to the affordance of certain perceptions and reactions in the user of the resulting image. These terms perception and *reaction* sum up two equally important aspects of expressivity as discussed here: information and affect. The picture both carries information about visual and other experience and promotes a certain relationship between the user and what is depicted. **The notion of carrying information is not—as we have seen—a simple channelling of data from the source to the user. On the contrary, at each stage, from the objectives to the idea, from model to view and from view to picture, subtle processes of transformation are at work. The proposed schema captures some of the richness and complexity of this pragmatic activity.**

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