The Four-Second Window:
Cognitive Science and Graphic Design

(draft)

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Preface

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By Pino Trogu

When I was a student of graphic design in the mid-1980s I took a mandatory course in the theoretical underpinnings of the subject, -- a system of thought called "semiotics," based on the ideas of the brilliant Swiss linguist Ferdinand de Saussure (1857-1913). Saussure was the father of the then influential movement called "structuralism." In its heyday, through the 1970s and 80s, structuralism was thought to hold the key to all human thought and culture, its influence spreading beyond linguistics into art, psychology, anthropology, literary theory and philosophy. Most of those fields have since moved past structuralism, as it became clear that its claims to explanatory universality were empirically incorrect.

A big exception to structuralism's fall from grace is my field -- graphic design – where theoretical conceptions are still dominated by semiotics, particularly in the work of Jacques Bertin whose monumental *Semiology of Graphics* (1967) is still a standard theoretical work in the field of data visualization in particular. One of my tasks in this book will be to show that such a-historical structuralism in graphic design is incorrect and misleading. But showing the defects of structuralist theories of design is only a secondary purpose of the book. Its primary purpose is to help designers understand the foundations of effective design with reference to its necessary cultural and psychological constraints.

In this effort of reconstruction, my two intellectual touchstones will be Ernst Gombrich in the historical-cultural dimension, and Alan Baddeley, in the psychological. Baddeley is the British psychologist, who has been called "Mr. Memory." I use these two figures simply as touchstones, not as gurus. Empirical science does not favor the guru principle, and my purpose is to connect graphic design with empirical science as well as with artistic excellence. Ernst Gombrich is at the center in such an effort because he combined vast art-historical learning with a deep knowledge of modern psychology. His theoretical account of the culturally-constructed character of visual representations is unsurpassed, and is consistent with present-day psychological science.

But Gombrich was born a few decades too early to include in his account the powerful limitations of short-term memory, more recently named "working memory" – the brief interlude when the human mind can put elements together in a meaningful way before they start receding from consciousness. First brought into wide attention by George A. Miller in his brilliant essay "The Magical Number Seven Plus or Minus Two" (1956), it has been one of the most fertile research projects in recent cognitive science. And the researcher whose account of working memory has been most useful and influential is Alan Baddeley.

This book is the fruit of many years of reading and thinking which have enabled me finally to

break away from the assumptions that I was taught as a student of design. The book attempts to show in brief compass how the constraints of cultural construction and cognitive limitation ("the four-second window") combine to foster excellence in graphic design, and how, when these are *not* taken into account, the communicative effectiveness of a graphic must fail. I hope that this effort of synthesis will help designers in their work and teaching as much as it has helped me and my students.

PT

Chapter 1

Introduction: The Four-Second Window

In 1956, the late great George A Miller came out with a brilliantly-written paper called "The Magical Number Seven Plus or Minus Two." It showed that when the mind is dealing with arrays of similar experiences like musical pitches, or pinches on your body, or dots in a frame, memory began to be unreliable once the number of objects reached five or so. Many years later, over on the web site of the great graphic designer Edward Tufte, there arose a good-natured, highly informative thread about the implications of Miller's discovery for graphic design. (See: http://www.edwardtufte.com/bboard/q-and-a-fetch-msg?msg_id=0000U6.) The post by Tufte was was labeled: "The magical number seven plus or minus two: Not relevant for design." The thread quoted an earlier letter from Miller himself, confirming that his work had been subject to significant misunderstanding – especially by the billboard industry.
Tufte was right to be skeptical about mechanical rules supposedly derived from Miller's work: such as the rule of 6-6-6 from The American College of Radiology which counsels its members in making presentations "Use no more than 6 words per bullet, six bullets per image, and six word slides in a row." Participants in the discussion pointed to successful graphics that seemed to contravene Miller's apparent limitations.

But not so fast! Miller's path-breaking work developed into one of the most informative and rewarding research programs in cognitive psychology. It has general application to the mind, and, being universal it has, when properly applied, relevance to graphic design. Originally called short-term memory, the name for this brief window of consciousness is now labeled "working memory." We know more about its structure and character than we did in Miller's day. And Miller himself, if he had been an actual participant in the Tufte thread would have pointed out that what constitutes an "item" in working memory could be as small as an "electron" or as multifaceted as "World War II." Even in its original manifestation, Miller's theory stressed the principle of "chunking" whereby dozens of items could become one item -- a phenomenon that can easily explain the apparent paradoxes cited by the graphic-design skeptics.

The key issue often missed in such discussions concerns the issue of closure ("clause" in grammar). If the items in working memory do not form into a meaningful unit within a span of time (the span varies, but for simplicity in this book we'll say here that it lasts four seconds) – unless that unification occurs within that four-second window, then the discrete items begin falling out of memory, and new impressions intervene. The experience will then have been uncertain and meaningless. But this severe limitation of working memory pertains only to the parts of an experience, not to the whole. *Anna Karenina* begins: *Happy families are all alike; every unhappy family is unhappy in its own way. Everything was in confusion in the Oblonskys' house. The wife had discovered that the husband was carrying on an intrigue with a French girl.* -- Nice direct, sentences with fast closure. Moreover the plotline is simple, direct, and

effective. So here we have a vast novel that is actually obeying Miller's strictures – which partly explains the novel's success. As I will show in discussing maps, there's essentially no limit to the number of discrete items in a graphic, so long as viewers achieve rapid meaningful closure at every stage of their viewing.

Convention, Ambiguity, Background Knowledge and Chunking.

Another theme of this book will be the historicity of graphic design. Until the graphic is interpreted by the viewer, it really isn't a meaningful graphic at all: In the interpretation process, the viewer brings to bear a complex system of expectations comprised of past experiences. Hence, in addition to the time limitation imposed by working memory, a second universal psychological principle in any visual or linguistic communication is that of the co-production of meaning by the viewer. Modern psychology tells us that perceiving and remembering are both productive acts based on past experience—an important insight that psychology has reconfirmed many times since the path-breaking book by F. C. Bartlett: *Remembering: a study in experimental and social psychology (1932)*. Bartlett included the idea of the socially shared expectations as part of the remembered event. The art of creating an effective graphic involves the successful social prediction by the designer of the kind of response the typical viewer will probably construct. Just as memory is not the passive reproduction of past events, but rather an active productive process, the experience of the graphic is not a passive activity but a productive one based on relevant past experiences by the viewer.

The two principles of working memory and the collaborative co-construction of meaning are always interacting in the communication. If the viewer is familiar with the subject matter, closure will occur much faster. Therefore it is important for the designer to include in the graphic the most appropriate and relevant information, instead of assuming that the viewer already has this information. The limitations of working memory can be reduced in large measure if the background knowledge brought in by the viewer is both highly familiar and relevant to the subject matter at hand.

That the very form of a design element is never a brute given is often illustrated by the famous rabbit-duck phenomenon, in which the form changes as one sees it first as a duck, then as a rabbit In *Cognition and Categorization* (Rosch & Lloyd, 1978), Eleanor Rosch and other researchers give scientific support to the principle that duck-rabbit style genre-classification is necessary to all meaningful perception. An overarching sense of the *kind of whole* we are seeing piecemeal through our momentary window of working memory is necessary to restrict the polysemy of words or images and quickly make ongoing sense of the parts.

George A. Miller once observed that the initial meaning that we posit for the word "shot" will be different, depending on whether the word is used on a golf course, a rifle range, or in a bar (Miller, 1999). His point has sometimes been oversimplified as exhibiting the special problem of homonyms in language – different words having the same sound: sun-son, tail-tale. But his point was far more general. Both words and visual images are always potentially *polysemous*, meaning that ambiguity always threatens. One of the designer's jobs is to supply what is needed to imply a certain kind of meaning. Genre provides a context, and context a genre: Is this a unisex restroom or a Jewish worship service?

Figure 1: Unisex restroom sign. Wikimedia Commons, 2013.

Convention, context, and genre all converge on the same function: Given the inherent polysemy of visual forms, genre and context, convention, all help reduce the inherent ambiguity of forms.

Cognitive science and history are thus telling us that the viewer's interpretation of a graphic or a text is highly dependent on elements in the viewer's long-term memory which are not themselves given in the graphic itself. This implies that all meaningful perception is not just reception but also construction based on prior knowledge. This insight proves that the principle of the historicity of design is correct, since the content of viewers' background knowledge changes over time. The more quickly accessible that relevant knowledge is, the more rapidly closure can be achieved. Cognitive scientists therefore lay great stress on the concept of *accessibility* (van der Helm & Leeuwenberg, 1991). It's up to the designer to invoke quickly accessible, that is, familiar, knowledge among the target viewers. While neither the designer nor the reader can modify the general time limitation of working memory, both can employ strategies to minimize its effects and maximize communication by adding enough familiar elements to provide accessible scaffolding that aids the viewing or learning process – titles, captions, labels, etc. – so that the material is interesting and challenging, but still approachable to the viewer. Amanda Cox, graphics editor of The New York Times, has termed this type of accessible scaffolding the *annotation layer* of a graphic (Cox, 2012).

The constructive character of perception is just as important, then, as the stringent temporal bottleneck of working memory. And the viewer's background knowledge[1] is the chief means of overcoming that bottleneck (Cleveland & McGill, 1984; Casner & Larkin, 1989; Carpenter & Shah, 1998; Cook, 2006; Canham & Hegarty, 2010; Hinze et al, 2013). While neither the designer nor the viewer can modify the general time limitation of working memory, both can employ culturally conditioned knowledge-based strategies to minimize its effects and maximize speed of closure.

1 Hinze et al, 2013. Beyond ball-and-stick: Students' processing of novel STEM visualizations. *Learning and instruction*, 26, 12–21. This quote from the abstract: 'These results indicate adoption and fluent use of visualizations is not given; rather, it is a function of prior knowledge and unfolding experience with presented content.'

'One millimeter equals six thousand men' – The theoretical significance of Minard's famous map

In the many pages that Jacques Bertin devotes to maps in his monumental *Semiology of Graphics*, nowhere do I find illustration or mention of what Edward Tufte (2006) considers to be the best, most path-breaking map in the history of graphic design: "Carte figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813", or "Figurative map of the successive losses in men of the French Army in the Russian campaign of 1812-13", drawn by the French engineer Charles Minard in 1869.

Why this remarkable omission in Bertin? One reason may be that he has other fish to fry. The achievement of his 19th century compatriot does not fit into his scheme. Bertin is interested in the "immediate" perceptual effects of definite forms, whereas Minard's perceptual effects are powerfully mediated by the viewer's knowledge. Bertin is aware of the temporal dimension of visual perception and its relation to memory. He even points out that 'a shorter observation time' makes a graphic construction more *efficient*. Nonetheless he tends to assign a 'natural and immediate perception' to the relationships among the three dimensions X Y Z, and he claims that the viewer's questions can be answered 'in a single instant of perception […] IN A SINGLE IMAGE' (Bertin, 1983: 139, xiv, 146). But all percepts are constructed; none is unmediated. Bertin's claim is imprecise, or metaphorical, or false. Minard's map is so clearly mediated by large quantity of relevant background knowledge stored in long-term memory of the viewer that his map is an excellent example of the general cognitive principles to be enunciated in this book..

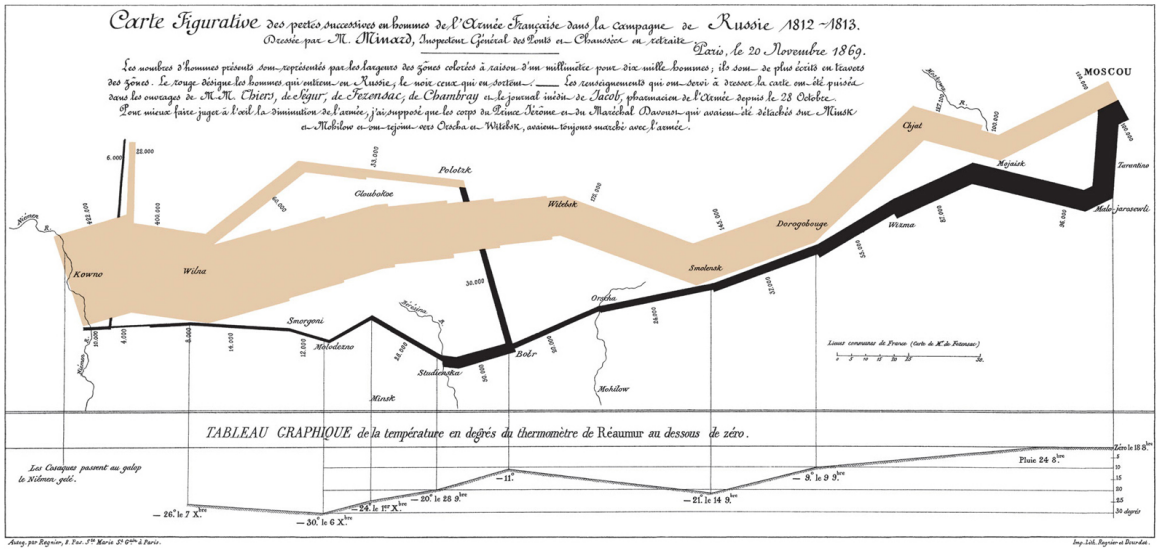


Figure 2: Charles Minard's map of the Russian campaign of 1812-13. Bibiothèque de l'école nationale des ponts et chaussée, Paris. Dim. 62.4 x 24.5 cm (24.5 x 9.6 inches). Wikimedia Commons, 2013.

In the diagram of the Russian campaign our normal idea of a map will be challenged immediately because the picture only vaguely resembles a map. And so it will take some time and effort to accept the varying thickness of a path – the colored line – as a statistical representation of the number of soldiers who are still alive at any point in the campaign. But as soon as that visual link between the line (the encoding) and the soldiers (the decoding) is established by the elaborate explanatory label – 'The number of men present is represented by the size of the colored zones with one millimeter representing six thousand men […]' (Minard, 1869) – we have no difficulty in sustaining it, and the abstract character of the line is no obstacle to the concrete understanding of the graphic and the appreciation of the story. Yet none of these meanings would come to fruition if the map were presented to a person – say a typical American 4th-grader – who had never heard of Napoleon or the Russian campaign. Minard could assume among his countrymen a tremendous number of associations which make these simple flow lines pregnant with meaning – and emotion!

Of course other means could be used to visualize that numerical variable, but why is this particular device so successful in aiding the viewer to make the connection and understand the graphic? How does the line work as a vivid representation of the data? An ancestor of Minard's changing line was the bar chart. It was invented by William Playfair and published in London in 1786 in his *Commercial and Political Atlas*. Minard's line is at the core a simple bar chart sorted and ordered by value (6K soldiers per mm) from highest to lowest, left to right until it reaches Moscow, and right to left on the journey back.

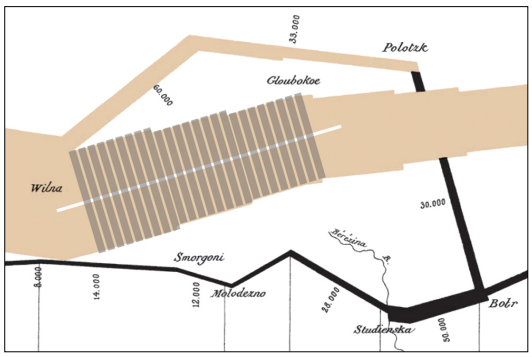


Figure 3: Minard's line can be described as a sequence of connected bars aligned at their midpoint.

Strictly speaking, the line is formed by a series of bars that have been joined together and aligned at their midpoint – especially in the top portion – instead of at the base, giving the figure its symmetrical, line-like quality (Fig. 3). It was a brilliant technical conception. But the horrific meaning of the graphic remains unseen. Minard's label, elaborate as it is, could not begin to describe the shared background knowledge, undepicted and unspoken, required to read this famous graphic. The viewer's background knowledge is thus a co-constructor of every graphic – not just of its ‚meaning but also of its form. For designers, one of the practical implications of this theme of background knowledge will be the cultural contingency of forms. What worked yesterday may not work today – not simply because fashions change but chiefly because the background knowledge of viewers – that universal co-constructor of every graphic -- changes over time.

A beautiful design that did not work

In 1972 the New York City Transit Authority introduced a beautiful map of its subway system that was radically different from previous ones (Fig. 4). It was introduced in 1972, but just seven years later, after many complaints from confused subway riders, it was discontinued and a new map issued, with a more traditional design that has survived to the present day basically unchanged (Lloyd & Ovenden, 2012).

The discontinued map was by the Italian designer Massimo Vignelli, and is regarded as a monument to modernism, a graphic nod to abstract art, and a model of simplicity, with its clean, bright-colored lines admitting only verticals, horizontals, and forty-five degree angles. The map is indeed a beauty to behold, a designer's counterpoint to Mondrian's *Broadway Boogie-Woogie* (Fig. 5).

Figure 4: New York City subway map, detail, 1972. Massimo Vignelli, designer. Revised: February 1978. Dim: 45 x 56 cm (18 x 22 inches). MTA, 1978.

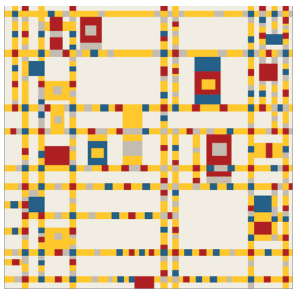


Figure 5: Piet Mondrian, Broadway Boogie-Woogie, 1943. Oil on canvas. Dim. 127 x 127 cm (50 x 50 inches), Museum of Modern Art, New York.

By contrast here is its more complex replacement (Fig. 6), which, with modest changes, has satisfied subway riders for the past 34 years.

Figure 6 New York City subway map, 1979. Michael Hertz, designer. Revised: Summer 1985. Dim: 58 x 71 cm (23 x 28 inches). MTA, 1985.

I'll try to explain why the Vignelli failed and why its replacement continues to succeed using the principles just outlined gleaned from art history, linguistics, and, cognitive psychology. I shall point to some general reasons for communicative success and failure in the world of graphic design – not to offer a formula for communicative and aesthetic success, but on the contrary, to show why historical and cultural considerations are always central to effective design.

The present New York subway map is an analogical representation of the network of train lines superimposed upon the familiar structure of New York's streets, parks, and rivers (Fig. 6). Vignelli's map (Fig. 4) had shown few details beyond the subway system; the replacement map includes all kinds of information: above-ground train lines, tunnels, parks, streets, airports, cemeteries – things belonging to the real world which the average user is trying to navigate.

But ask a three-year old from a small rural town which of these two pictures she prefers, and the answer might well be the abstract Vignelli – depending on whether she likes straight lines rather than curves. And there's a further subtlety: there's no principled reason why a schematic representation – more sensitively executed – could not have worked. One could very well make one's way in New York with a schematic map, just as one does in Paris, whose Metro uses a somewhat similar schematism which like Vignelli's also emphasizes the rail system rather than the underlying topography (Fig. 7).

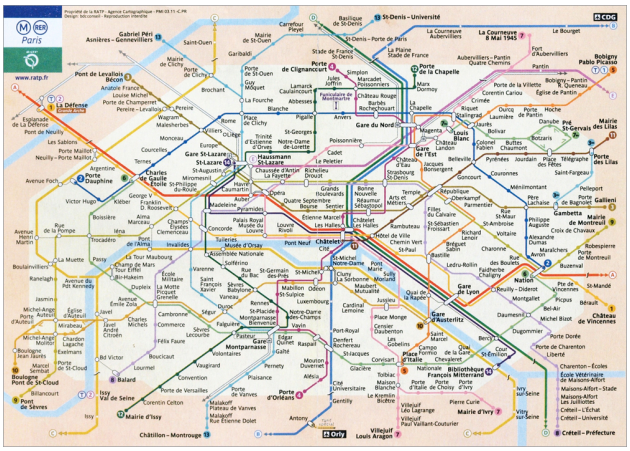


Figure 7: Paris metro map. RATP (Régie autonome des transports parisiens), 2005.

Or in London:

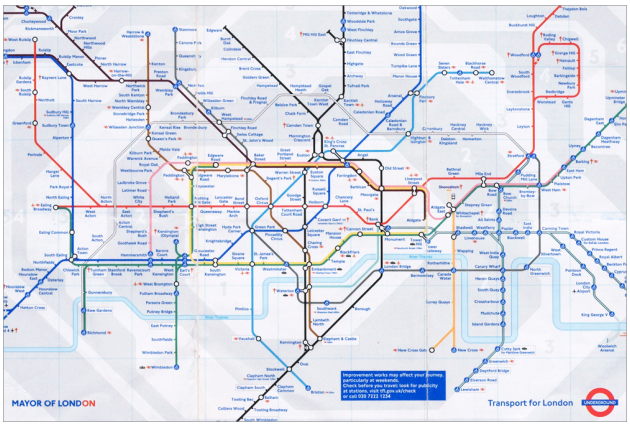


Figure 8: London underground tube map, detail. Transport for London, 2007.

This London map which essentially reproduces Beck's original design of 1931, is a durable 82 years old and still going strong (Fig. 8).

Why then, did the abstract schematic in London and Paris succeed, while Vignelli's failed? The basic answer must lie in the way Vignelli thwarted the viewers' conventional expectations. All maps from Babylon to Google are conventional. For instance, to orient maps northward is a late convention of modern Europe, and earlier in the European Middle Ages, and right up through the Renaissance it was not north but east, (where Jerusalem lay) that was at the top. In fact the very word "orientation" means "pointed to the east." In China the top was south. To use a map one needs already to know such conventions to orient oneself in space. In a purely river city, like London or Paris surrounded by land, one needs only a schematic representation of the defining river to achieve orientation in real space. If the land area depicted is lengthened or foreshortened here and there to magnify the busy center, the schematic of the river still enables one to feel oriented in space.

New York City is topologically different. Manhattan Island and its surrounding boroughs are far less simple geographically than the river-based topography of Paris and London. And to compound that inherent problem, Vignelli's version of a schematic representation defies conventional references to topographical reality. He imposes an imaginary white amoeba to represent a very elaborate land complex. Then, only after careful study – long after one has missed one's subway stop – does one realize that those gray-brown splotches on his map are supposed to be water. This completely overturns the conventional water-is-blue-land-is-brown expectations of his viewers, and further confuses them.

He thus fails to help the viewers orient themselves in space – surely a conventional requirement of a map, going back to the first known maps of Babylonia (Fig. 9) up to the famous Steinberg New Yorker cover. We always read maps looking for a "You Are Here" spot.

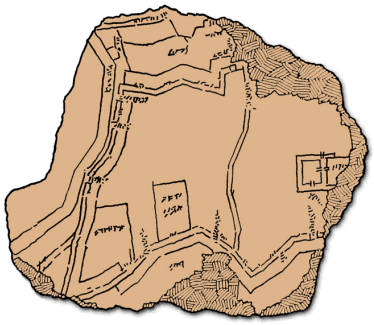


Figure 9: Town plan of Nippur, Babylonia, clay tablet, 1300 B.C. The earliest known map drawn to scale. Hilprecht Collection, Friedrich Schiller University Jena, Germany.

This means that a normal expectation and convention of maps is isomorphism. Any area on the map will have a roughly corresponding area on the earth, with roughly accurate relative magnitude and direction in relation to other represented areas. This convention has been picked up by cognitive-minded industrial designers who termed it *natural mapping*, and applied it to the intuitive arrangement of control knobs, levers and switches on devices as diverse of stovetops, airplane cockpits, and car doors (Norman, 1988: 75-80).

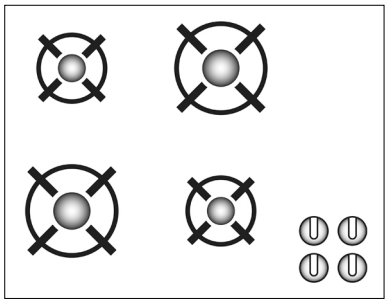


Figure 10: The control knobs in this stovetop are naturally mapped to the corresponding burners, requiring very little cognitive load to perform the desired action. (Norman, 1988)

In the London and Paris subway maps this isomorphic relation is stretched, but not abandoned. In the Vignelli map with no detectable water and with Central Park changed from a rectangle to a square, the isomorphic relations are stretched so far that viewers can't map even approximately or correlate their positions on earth with their imagined positions on the map. New Yorkers were schooled in map conventions, in water being blue, and in their position on earth being related to their position on the subway map. The thwarting of these conventions was bound to induce the confusion the New Yorker's complained of, which prevented closure. They were too knowledgeable; they knew too much about isomorphic map conventions and New York geography, and blue water, and the defeat of their expectations caused massive confusion. To defy those expectations was naïve on Vignelli's part, and reflected the a-social naiveté of modernism. One could hardly invent a better example of a designer's failure to meet the primary communicative obligation to work with the conventions, expectations and background knowledge of prospective viewers

These examples introduce some of the chief themes of the chapters to follow: that an a-historical approach to design such as semiotics offers inadequate, and indeed misleading guidance because history is a co-constructor of meaning and form. I'll show in detail why neglect of basic principles of cognition has been similarly misleading. I shall argue that recent cognitive science helps explain why some graphics work while others do not, how the verbal element is present in the visual, even in those parts of a graphic that lack words, and why the notion that a graphic is a simultaneous presentation to the mind is a myth. These and other results from recent research show also that forms are universal communicators is also a myth. Based on this updated approach to the subject, I offer in the final chapter some practical advice to designers.

Chapter 2

The Omnipresence of the Verbal

A rare, sad condition caused by tissue destruction in the brain is called associative visual agnosia. People with this condition are able to recognize visual representations, but they cannot identify what the images represent. Their visual and their verbal systems have been physically dissevered. For the rest of us, fortunately, the verbal and visual systems are physically hardwired, and mentally intertwined. We know this from priming experiments which show that milliseconds exposure to visual images speeds up relevant verbal comprehension, and milliseconds exposure to written words speeds up picture identifications. (Hirschfeld et al. 2011)

Alan Baddeley, who has conducted memory research for several decades, has developed a well-accepted model of working memory that consists of two basic components. (Baddeley, 1999: 49-66) One is the articulatory or phonological loop that provides a temporary verbal storage, even in the case of visually presented materials. He found that we unconsciously name objects as they are presented in a process called "sub-vocalization" – a kind of inner speech. It's been shown since the 1970s that we subvocalize when viewing pictures. (Noizet & Pynte, 1976) Such naming plays a strong role for gaining rapid closure in the successful perception of a visual organization, just as it does in the understanding of a verbal organization. (Logie, 1996) In short, every act of meaningful visual perception requires time, and is usually accompanied by unconscious subvocalization. It's useful for designers to be aware of how universal this phenomenon is. The silent act of looking at pictures is accompanied by an activity of inner speech, just as silent reading is. (Baddeley 1999)

The other component of working memory, is the visuo-spatial sketch pad involved in temporary retention of visual and spatial information. 'As the phonological loop has been linked to the speech system, the visuo-spatial sketch pad has been linked to the control and production of physical movement.' (Logie, 1996: 53) The tight visual-verbal interaction that takes place within the process of working memory suggests a distributed effort among all the components of the system, especially between the phonological loop and the visuo-spatial sketch pad.

And here's a key point for designers: the role of the verbal seems to be just as important as the visual in processing visual information. Quick recognition of representations is connected with quick naming of them – a feature that can be reinforced in graphic design with its extensive use of text. Lessing's remark in his *Laocoön* of 1766: 'that succession of time is the department of the poet, as space is that of the painter," will need to be greatly modified.

Lessing had a point of course in that the temporal nature of language is fixed. One still reads words in a definite sequence, and paintings and sculptures in an indefinite sequence. Hence it's reasonable to speak of theater, poetry, and cinema, as time-based arts, and painting, sculpture, or graphic design, as space-based ones. But Lessing discovered only a convenient half-truth. Interpreting the spatial is a temporal process like any other psychological process. The various parts of every painting, poster, map, are "read" sequentially – just not necessarily in a fixed order.

We instinctually know that "reading a book" requires time and that it is an elaborate process, but we generally approach a poster or image with the expectation that these will communicate to us more quickly, almost instantaneously. But the designer needs to know that both the temporal-verbal plays a central role in the perception of images. Thus it's a very practical consideration for the writer, artist, or designer to be aware that time will be needed, that it will be limited, and that closure at every point has to happen within a very few seconds.

In chapter 1 I pointed out that the limitations of working memory are overcome not simply by reducing the *number* of items that have to be processed by the viewers at any moment. It's also necessary to speed up that processing time through design elements that communicate fast because they are immediately familiar to the audience. With respect to processing time, fast semantic closure is just as important as fast iconic closure, and both depend on viewers' familarity with forms and conventions. Fast closure can only be achieved by the use of conventions and associations that will be quickly interpreted by the viewer.

This rapid semantic closure is determined less by the operations of working memory than by the contents of the viewer's long-term memory. This critical domain of long term memory is in the end is even more significant for effective design than is working memory. Working memory simply rents out the room. Whether the incoming elements mate before they fade away depends on how quickly they enter the room and how well they know each other.
A generation ago Endel Tulving and his colleagues made the important distinction between elements in long term memory that are available and those that are not only available but are also quickly accessible. Only elements that have been made accessible are likely to enter the room in time when viewing a graphic. According to psychological experiments, available elements can be made accessible through priming – by introducing a relevant clue in the graphic that will enhance speed of retrieval from long term memory. Language and image prime each other for rapid accessibility. The designer needs to exploit this symbiosis of language and image to the hilt.

Verbal and Visual: Saussure's contribution

The Swiss linguist Ferdinand de Saussure (the great forebear of structualism) pointed out the fundamental arbitrariness of a linguistic sign – a word, an image, etc. "It is because the linguistic sign is arbitrary that it knows no other law than that of tradition, and because it is founded upon tradition that it can be arbitrary." (de Saussure 1986) He was very specific in describing the 'linguistic sign' as something that "…is not a link between a thing and a name, but between a concept and a sound pattern." (de Saussure 1986, p. 66) This suggests that the sound pattern of a word is the first thing we access when we make connections and associations in our brain and that when we interpret a sign we are probably accessing that existing knowledge of the word as a sound-image – one of the translations of Saussure's term *image acoustique* – stored in long-term memory. Saussure's large-scale analysis of these relationships is quite consistent with current cognitive science.

Understanding becomes an act of remembering that combines past concepts with the material at hand and quickly builds and creates new knowledge. The experience of a given graphic in a specific time and place is not an instantaneous event, but relates to past private events (personal knowledge) as well as shared convention: the accepted and agreed-upon value of words and

images and their use within sentences and spatial arrangements. Saussure went on to term the connection between words and images as they relate to our long-term memory and past experience as 'associative' or 'paradigmatic' relations. (de Saussure 1986, p. 122) He distinguished them from those relations occurring between words and images which are possible by virtue of their relative position within a given, ordered sequence (a spoken sentence) or by virtue of their specific spatial arrangement (the elements of a house, a painting, or a graphic). He termed the latter 'syntagmatic relations'. His simple example of this distinction was that of a Greek temple with a column supporting an architrave: an image illustrating a syntagmatic relation. But if the column was Doric, he continued, such image might evoke a comparison with the other classical architectural orders of Ionic and Corinthian and this would illustrate relations of the associative type.

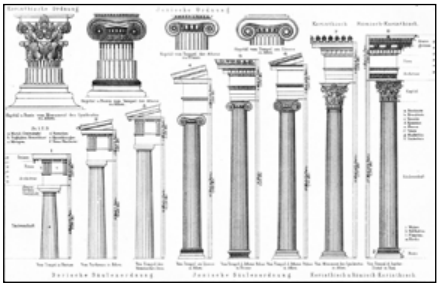


Figure 11: Doric temple & Greek architectural orders.

A parallel exists between Saussure's concept of associative ("paradigmatic") relations and the concept of familiarity and relevant background knowledge:

> Outside the context of discourse, words having something in common are associated together in the memory. In this way they form groups, the members of which may be related in various ways. […] This kind of connection between words is of quite a different order. It is not based on linear sequence. It is a connection in the brain. Such connections are part of that accumulated store which is the form the language takes in an individual's brain. We shall call these associative relations." (de Saussure 1986, p. 122-23)

Saussure's use of the terms 'accumulated store' or inner storehouse (de Saussure 1959) dates back to his lectures at the University of Geneva between 1906 and 1911, but it seems a perfect fit for the concept of long-term memory currently used by cognitive psychologists.

Dissonance Between Verbal and Visual.

Some well-known psychological experiments with verbal and visual elements are quite pertinent to design decisions. In December of 1935, J. Ridley Stroop reported a series of "interference experiments" which showed that the processing time and accuracy of perceptions were greatly slowed down or corrupted when there was a conflict between the visual and verbal inputs. In a typical experiment, the word "BLUE" might be printed on a red card, or vice versa. Such conflicts greatly reduced the speed and accuracy of performance. Ingenious Stroop-style studies have been carried on ever since with consistent results. Verbal-visual conflicts cause significant delays in processing time. The 75-year long series of still-ongoing

experiments have been designed to determine with ever greater precision the underlying neural mechanisms of the significant interference effects.

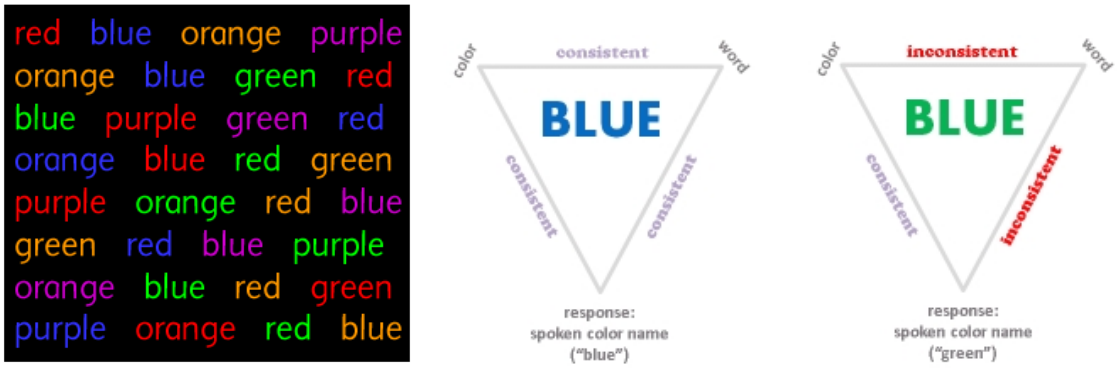


Figure 12: The Stroop effect.

There are more subtle ways in which such interference can occur less directly when other conventions besides those of language conventions are in conflict in a graphic -- as when Vignelli colored his water tan and his land masses white:

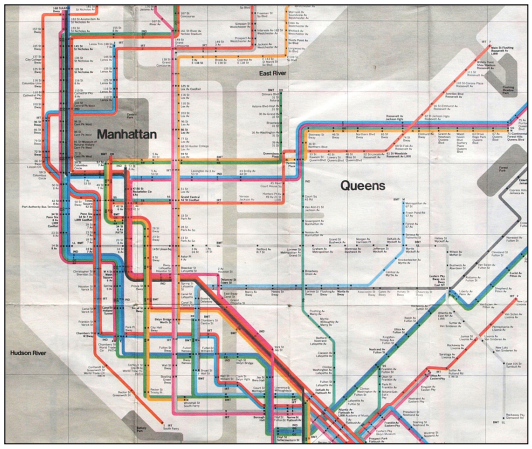


Figure 13: The New York Subway map, 1972.

In the example shown in Fig. 14, a particular type of imagery was chosen to illustrate an event involving art school alumni reviewing the work of current young students. Here, while the text is rather direct and descriptive, the images that should support the text are themselves completely unrelated to the topic. A graphic show is not a cordoned-off crime scene. While it's true that sometimes free associations can make for memorable images – John Blake's image of a cow on Pink Floyd's Atom Heart Mother record album cover from 1917 is one example – this does not always work. For if one describes aloud the police crime scene depicted in the portfolio night poster, what should one make of it? Is reviewing student work an illegal activity? The meaning of this image is neither related to the text, nor is it ironic, and neither it's a parody

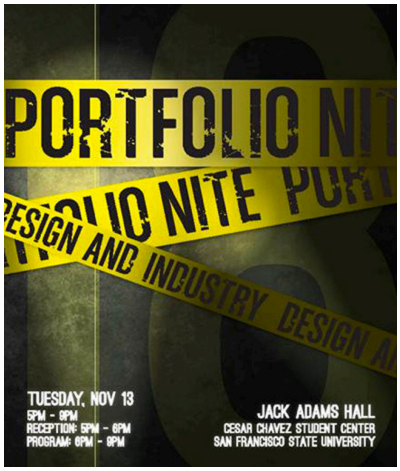


Figure 14: Do not bungle the meaning: design school or police academy? Design and Industry department, San Francisco State University. (AIGA student chapter, used with permission)

Another image from an advertisement for a book that promises a Modern approach to learning seems to go squarely against its advertised goods (Fig. 15). The book offers a "counterintuitive resource that joins the brain's connections to the nature of learning with the art of teaching" for very cutting edge, innovative research. Yet the cover offers the most traditional of education related imagery: an apple and a stack of books of the physical kind. I suspect that the publisher, more akin to marketing then the author, opted for an instantly recognizable image that says education, but never mind if the alternative part likely pushed by the author was left out. This is a contradictory verbal–visual message, although having not read the book yet, it is too early to judge this one by its cover. (The New York Times Review of Books, Sunday, August 11, 2013)

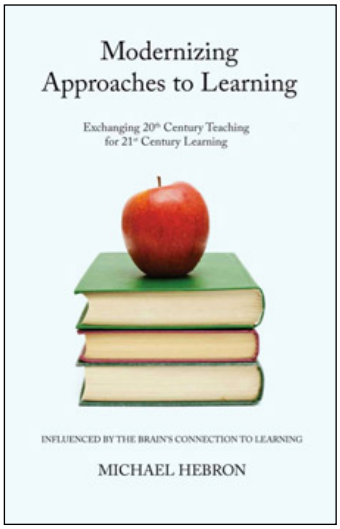


Figure 15: Modernizing Approaches to Learning book cover.

The problem of verbal-visual dissonance was brought home to the comedian Chuck Henley of Saturday Night Live found out when he first purchased a custom license plate to read PTHOTS . "Handey is best known as the writer and performer of "Deep Thoughts," a series of quasi-philosophical cracked aphorisms that ran on "Saturday Night Live" from 1991 to 1998. The license plate on Handey's car is DPTHOTS; on the wall of the garage is mounted the plate he purchased initially but never used: DEEPTHT. That's because the day Handey was screwing it on, Handey's brother-in-law asked, "Why does your license plate say 'Deep Throat'? (Dan Kois, New York Times Magazine, July 15, 2013)

These examples of bungled or dissonant meanings show how difficult it is to make good rules of thumb in graphic design in purely formal terms. The dissonant crime-scene image and the dissonant book-apple image are quite acceptable in formal terms. It's the verbal/semantic connotations of the images that create dissonance. Good designers like good writers need to look beyond the immediate systems of associations in their own minds, and ask themselves whether this same system of associations is quickly accessible to the probable viewers. This projection out into the collective mind of the reader/viewer is the first lesson of the teacher of writing, and it needs to be an early lesson of the teacher of design, who is, as we have seen, also a teacher of writing!

Verbal and Visual: The Geico commercials

This structural connection between the visual with the verbal is especially salient when the design elements use letters. Today the American insurance company GEICO is remembered by consumers, among other things, through the link between the sound of the word GEICO and the sound of the word gecko. (GEICO, 2012) An anthropomorphic gecko is one of the spokespersons featured in the company's advertisements. The ad series started with a play on mistaken identity and wrong phone numbers (Geico, gecko?) and the mnemonic power of this sound similarity has sustained the effectiveness of the campaign. The novelty in the ads is the human-like gecko – already a charming character – but the ad works because people remember GEICO and the sound associated with it by remembering the sound associated with gecko. Although made with advanced computer visuals, the ads work first and foremost on the aural dimension of the words that are spoken in various kinds of British accents.

Figure 16: GEICO. Government Employee Insurance Company, USA.

The ad works not because the word GEICO stands for Government Employee Insurance Company and the word gecko stands for the animal, but because the sound pattern linked to the concept of gecko the animal is similar to the sound pattern linked to GEICO the insurance company. This vocalized image is what makes us remember GEICO the company. The written words in a graphic should ideally be spoken aloud by the designer to test their clarity and avoid any semantic dissonance, and also to avoid bungling the meaning whereby a contradictory or confusing message is communicated to the viewer through the use of completely unrelated text or imagery.

Advice to the designer: Read the text aloud and "name" or describe the images in the presentation. Do the text and the images say what you, the designer intends to say and is it what your audience should understand? In other words, is the meaning of the piece the meaning you intended, or is it something else? The verbal, aural dimension of every picture helps to formulate the answer to that question.

Chapter 3

The Myth of Simultaneity

The mind map, also known as concept map is based on the principle of simultaneity of visual perception – on "getting the picture" all at once – in contrast to verbal processing which is linear and takes time. The device, which was popularized in 1984 by Novak and Gowin, has become a staple of the design process, influencing decision-making from the classroom to the corporate boardroom. The idea of the simultaneity of visual perception has a storied pedigree in some of the most influential artist and thinkers of the twentieth century: Paul Rand, Laszlo Moholy-Nagy, and Marshall McLuhan to name but a few. But such a contrast between the visual and the verbal belongs to Lessing and the 18th century. We now know that the visual and the verbal – the spatial and the temporal – are enmeshed with each other in human perception. As with many design fashions there's essentially no scientific evidence of the efficacy of mind maps. In fact, as I'll show in due course, the scientific evidence goes the other way.

In 2009, in the preface to his book *Change by Design* Tim Brown, the influential head of the global design firm IDEO, offered his readers a visual "mind map" as an alternative to an ordinary verbal table of contents.

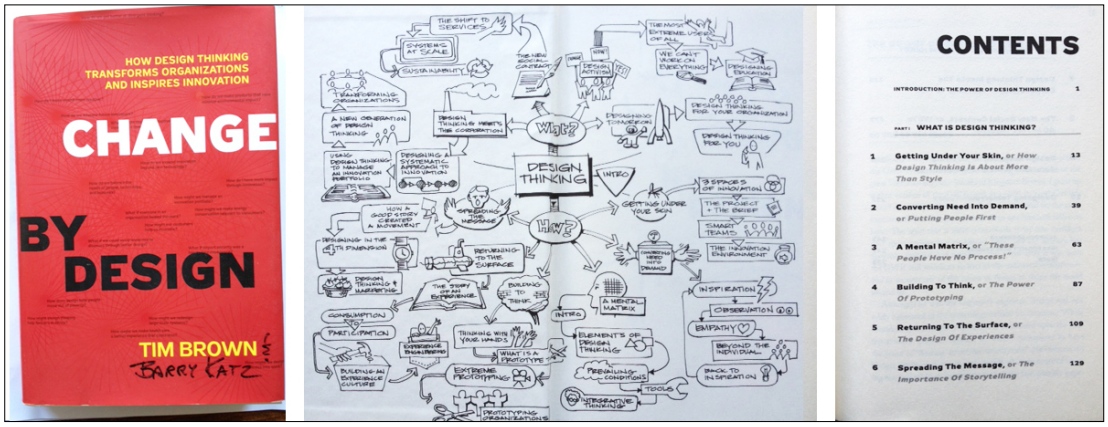


Figure 17: Change by design. Book cover, inside cover, and table of contents. 2009. Tim Brown.

Nonetheless we now know that the mind cannot possibly take in all at once a system of relationships with dozens of elements. Whereas Tim Brown considers his spatialized table of contents to be a helpful picture, a less theory-driven orientation to design (or a more accurate theory) might simply recognize it as confusing.

This example affords a window into several major problems with mind maps. The first

problem is their lack of isomorphism with what they refer to. In a geographic map, there is a rough isomorphism between the visual elements in the map and their corresponding referents on the earth. The misplaced analogy (Novak) between a classic automotive road map and an abstract concept map misses the fact that what makes a traditional map work, despite its complex arrangement of layers and hundreds if not thousands of individual items, is the isomorphic correspondence between the map and the real world. Safely within the bounds of working memory, the viewer navigates a very selective personal path: from point A to point B in relation to a you-are-here spot.

All good maps refer back to the you-are-here spot, and it's quickly evident that the mind map does not. By contrast, the Table of Contents does. In the case of Tim Brown's graphic, the TOC is paradoxically a much better, more isomorphic, roadmap to the intellectual journey which is the book. In the world that is referred to – the book -- finding one's way by means of the table of contents will be much easier than trying to do so from a concept map that does not resemble the fixed progression of the fixed sequence of chapters.

Proponents of mind maps say that the design process is all about making connections, and that a mind map can serve as a better model than the traditional linear TOC. In fact, the reverse is true. The fixed form of the TOC is isomorphic with the fixed form of the text. Yet, at the same time, it "reserves the right" to the infinite connections afforded by the inherent openness of the text. Although the text is fixed and sequential like the TOC, it remains open to a multitude of relationships at every point.

By contrast, the frozen-in-place relationships of the mind map limit the connection-making process. Like a second-rate movie based on a complex book, the mind map compels a two-dimensional system of connections. On the one hand it is too complex and confusing because it exceeds the limits of working memory, while on the other hand it is too simple and limiting as a depiction of concept-relationships.

Another type of mind map is offered by Hugh Dubberly.

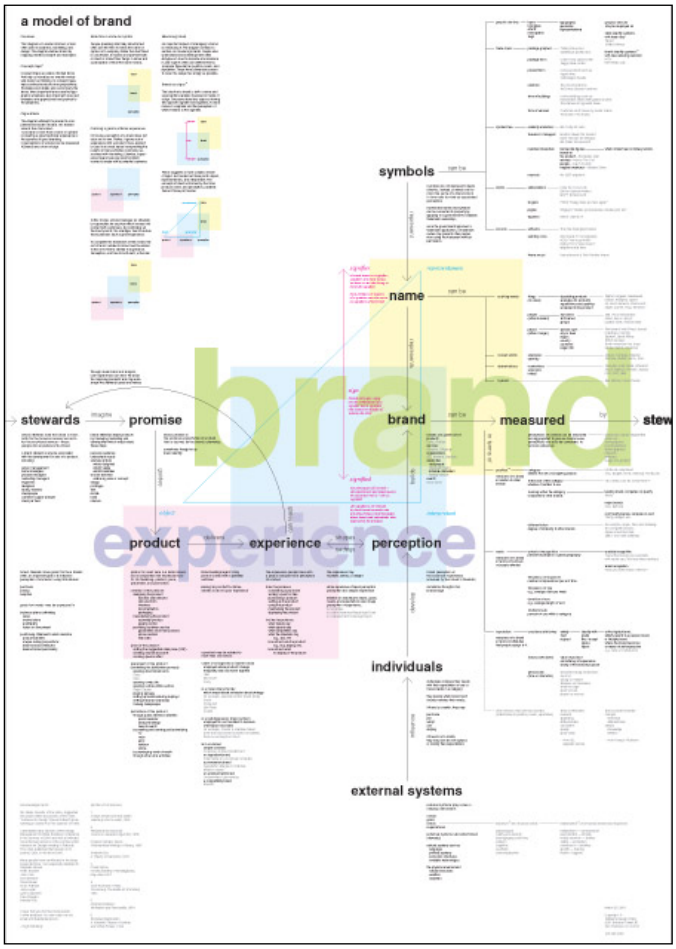


Figure 18: Model of a brand concept map, 2001. Hugh Dubberly.

This *Model of a Brand,* figures prominently in the final chapter of the recent and comprehensive *Graphic Design Theory* textbook by the influential design educator and theorist Meredith Davis (2012, p.227). Here the concept of a brand is supposedly distilled down to a single, simultaneous presentation. While the sizes of the words "brand" and "experience" allude to the new presentation method of the word cloud (which is effective in other contexts because it is a genuine mapping between word frequency and type size) using the word-cloud technique is confusing since Dubberly is not mapping word frequency, and in fact gives approximately equal analytical status to "experience" and "brand," further confounding confusion.

Instead of trying to ferret out just what Dubberly aims to communicate here, or showing again how far the mind map exceeds our mental processing capacities, I'll point to another defect of word lists like this, a defect that was first pointed out by Saussure – the confusion that people make between *langue* and *parole*.

Parole refers to the actual utterances we speak – sentences with (explicit or implied) subjects and predicates. *Langue* is the whole shared mental convention-system for a speech community at any point in time which enables *paroles* to be spoken, written, and understood. Before Saussure, people had not been clear about these two dimensions of "language." His *langue-parole* distinction was path-breaking and illuminating.

According to modern cognitive science, Saussure was right in thinking that meaning resides in the back and forth between what is seen or heard on the occasion and what is stored in the mind as a shared "system" of conventions, associations, etc. as part of long-term memory. Modern researchers would say however that Saussure missed the mark in thinking that the shared system of conventions and associations could be codified in a structure similar to the phonemic structure of language.

Although the psychologist Thomas Landauer has had modest success in finding mathematical regularities in the way words are associated in existing texts, the *semantic* structure of language isn't a codifiable system, as Saussure thought. It is, rather, highly variable and context-dependent. The referents of language, the "blooming buzzing confusion" William James spoke of, can't easily be codified. Yet Saussure was deeply right about the difference between *langue* as a system of possibilities, and *parole*, as a realization of some of them in actual usage.

Concept maps like Dubberly's miss or ignore Saussure's epochal distinction between *langue* and *parole*. Sentences and not individual words are the basic building blocks of speech. In these mind-map designs we are left with a vague visual representation of *langue*, but no *paroles*, no real speech. We are given something like the contents of those magnetic "poetry sets" with which one makes up sentences or even poetry if so gifted. The words by themselves simply do not communicate. The "connections" supposedly afforded by the spatial arrangement of concept maps, that is, the various possible "paroles" (many possible paths) remain in the abstract area of shared possibilities – all commercial and no program – al *langue* and no *parole*.

Nothing is simultaneous in perception. Concept maps confuse lists of words (mere uncertain potentialities) with actual utterances. The little necessary bits that convert *langue* into *paroles* are absent -- conjunctions, articles, and prepositions are eliminated. Because of this pruning and mutilation, the traditional sentence structure is absent, and no specific word sequence or order is left, but only a general arrangement of words, like a speech that leaves out the little tidbits like verbs, articles and conjunctions. Listening to such a speech is like sorting through the mess of a shredder's bin. *Langue* doesn't communicate, only *paroles* do/. The concept map leaves the viewer to create the *paroles*, which takes a lot of effort, and time, and causes one to forget where one is or what one has done. Instead of gliding with simultaneity, we stumble with excess processing time.

As my final example of the inadequacy of concept maps, here's one *about* concept maps.

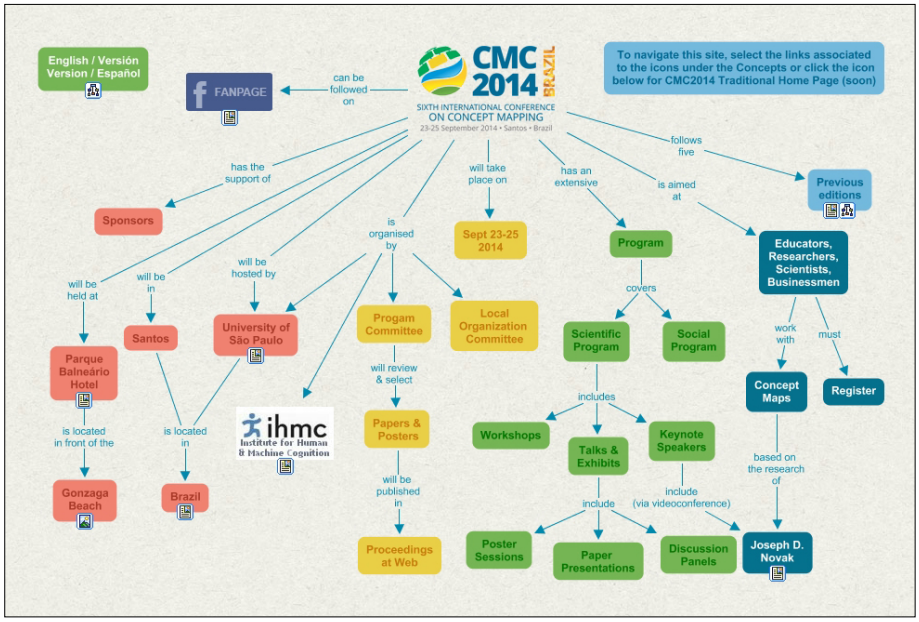


Figure 19: Home page of the 6th International Conference on Concept Mapping (CMC 2014 Brazil).

This web site ad for a concept-map conference is made beautiful by the addition of color. It also claims to be "revolutionary." Readers can judge for themselves just how effective this "simultaneous" presentation is in explaining the conference. A direct transmission of its message from left to right says: "The conference has the support of unnamed sponsors. It will be held at a beach hotel in Santos, Brazil. It will be hosted by the University of Sao Paulo, etc. etc." No sense can be made of its message until *after* these linguistic translations have been made – a process that is very time consuming. In other words, instead of presenting a message to the mind all at once – the myth of simultaneity—it forces the mind to take more time to understand the message than a few direct, simple sentences.

This graphic also exhibits the typical implicit claim to scientific validity. The conference is partly sponsored by a branch of the Florida University System called the "Florida Institute for Human and Machine Cognition." But science does not support this system of representation. "Concept map" is a fundamental misnomer. The design does not map concepts; it very inadequately maps sentences. The actual nature of concepts, a topic of much study and research, is neither linguistic nor pictorial, but rather propositional, and temporal. (For a full discussion and bibliography: http://plato.stanford.edu/entries/language-thought/#ConDeb.) Moreover cognitive science also tells us that what we actually remember from concept maps are not concepts but an image of little boxes or ovals with lines between them. Like Tolstoy's happy families, concept maps are all alike. They have completely unearned scientific pretensions. They are an unfortunate fad.

The myth of simultaneity" from modernism to post-modernism to "infographics"

Which of these two representations of quantity will be processed faster by the viewer?

1/3

Or

••••……

In my final chapter, "Rules You Can Use," here are two injunctions from Rule 16: "Do not use repeated little dots to represent numbers." "Do not use repeated little icons to represent numbers."

A fundamental insight of George A. Miller was that the chief way of overcoming the limitations of working memory is the process of chunking – devising ways of unifying several things into a single thing, thus reducing the number of elements the mind has to deal with all at once. Hence 1/3 is a chunked version of the little dots **....**..... Using use the little dots is an unchunking of the fractional concept. Some recent designers, under the misapprehension that dots, because visual, are processed simultaneously, show an unfortunate tendency to reverse Miller's insight and to unchunk a unitary idea into multiple elements – thus increasing processing time.

Perhaps one the most overused, and abused, graphic device currently used by national data journalists and designers and information design students alike, is the so called system of "isotypes" developed in the middle of the 20th Century by Otto and Marie Neurath in England.

Isotypes are quite familiar, being found in pictograms such as restroom signs or the sports icons of the Olympic Games. Like many good ideas taken too far, the beautiful graphic work of the Neuraths, especially in children's books and readers, has been overshadowed by the indiscriminate use of little men, little women, little children, all endlessly lined up in the rank of a dignitary's military reception.

The method can sometimes be useful, when used sparingly:

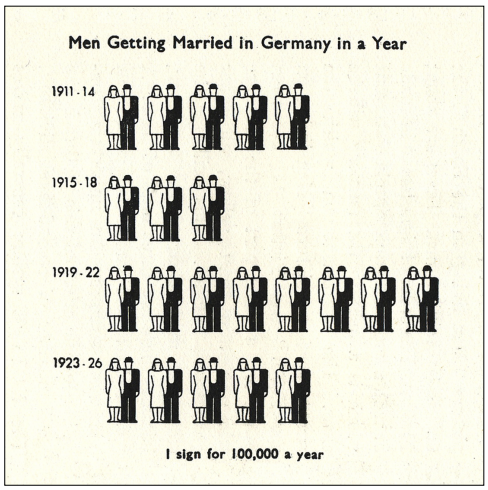
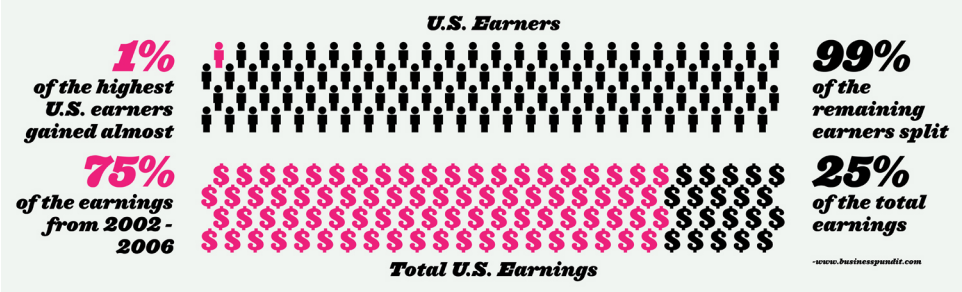


Figure 20: Example of Otto Neurath's isotype system to represent statistical data.

But even in this example we are faced with the mental math task of having to multiply each couple in a row by one hundred thousand. So for the first row we get 500,000. Now we have to repeat this operation for the second row: 300,000. Other problems such as the representation of fractions and smaller numbers will soon become a quandary, save the blunt chopping up of the figures into whatever smaller body parts become necessary, as this problem is normally solved. Where is Descartes when we need him? A simple X axis at the bottom with some number labels is all that would be needed to make this graph more useful. Better yet: use a bar chart!

The two examples below are details from student work that has been influenced by the Neurath-derived trend of using little people and little squares to represent quantities, and what's much even worse to represent proportions. (I say in rule 16: "Bring back the humble, delicious pie! We don't use pebbles to count anymore, and we have invented a tool called "place value". It's better to write out the number or to visualize it using a single solid area, not many tiny areas in little rows. Do not use little people as units to show quantities, even if the quantities represent people. Think of those poor little guys whose limbs get mutilated when you have to represent a fraction: arms, legs, even heads get cut off without mercy!"



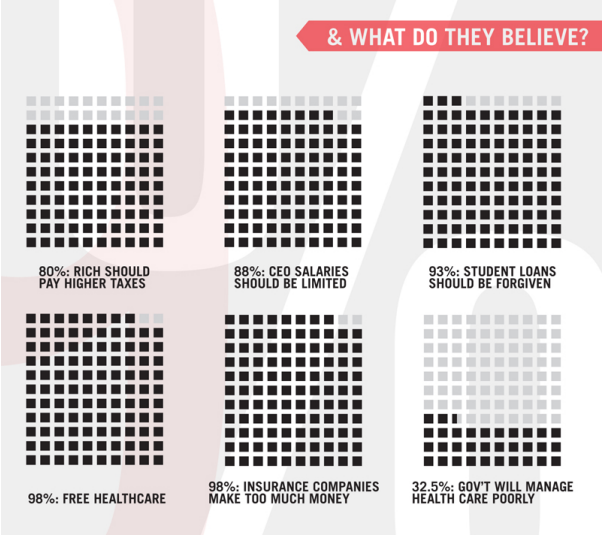


Figure 21 Neurath's derived infographic devices, like the endless repetition of little squares, force a huge cognitive loads on the mind of the viewer.

Little dots or little people are very popular in mainstream publications like Time magazine. What shall we make of the little dots on the bottom of the circles (Fig. 22) in this overloaded and confusing graphic?

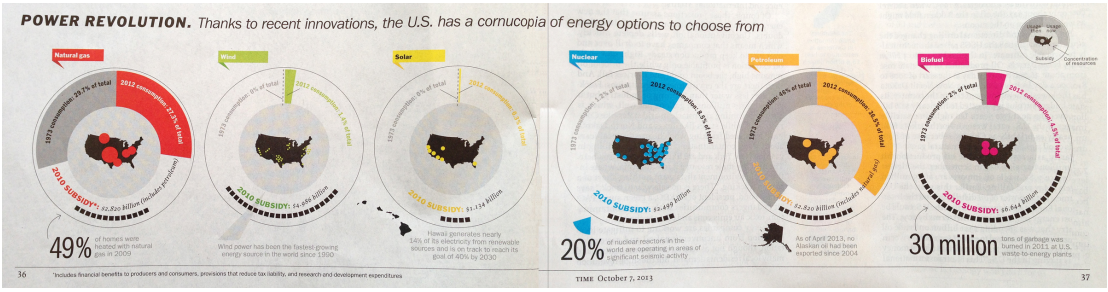


Figure 22 Power revolution infographic. Time magazine, Oct. 7, 2013, pp 36-37.

This graphic was published in Time magazine on Oct. 7, 2013. In it, there are so many incongruous and perplexing graphic devices, that a whole chapter could be devoted to its analysis. The graph compares the consumption of various types of energies (natural gas, wind, etc) between 1973 and 2012 and represents those quantities with different slices moving symmetrically from the 12 'o clock position. So these are more or less pies with slices, but the remaining "slices", the bottom part, is used to represent the amount of government subsidies to the various industries. Slices inside slices, especially when referring to different sets of data, is a bad idea. To explain the bottleneck, the last pie at far right shows that in the US in 2010, the subsidy for biofuel was $6.644 billion. Never mind that the print is so tiny that one reads the huge "$30 million" – tons of garbage burned – to be the label for the dots, courtesy of the misleading arrow pointing to the pie and the gray caption getting disconnected from its number picture.

There is simply no way that our mind can visualize six billion by looking at -- are you ready? -- 29 little squares. Even when the comparison is made visually with the other pies and rows of dots, the urge to "count the dots" is simply too great and an obviously extraneous and intensive cognitive task that will slow down the process of closure to a crawl if not outright stall. A quick proportion between the pies reveals the puzzling result that one little square is equal to about $220 million. What kind of reference point is that?

Historically speaking, the myth of simultaneity has overtaken the modernist ideal of simplicity. Here, side by side are two examples of this regressive history, the first from 1962, the second from 1988.

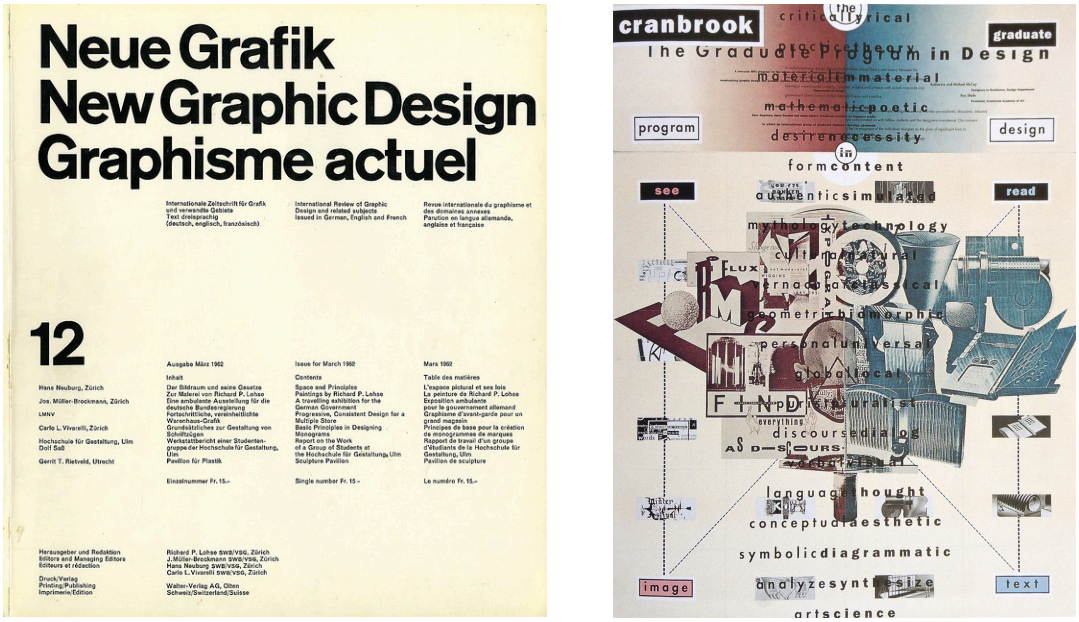


Figure 23: Left: Neue Grafik, 1952. Right: Cranbrook Academy of Art, The Graduate Program in Design. Katherine McCoy, 1988.

I leave it to the reader to decide whether this sequence represents progress in the communicability of graphic designs. The movement from the first to the second image indicates a transition from a modern to a post-modern aesthetic. Reading the second image, it quickly becomes evident that too many items are presented simultaneously and without a definite progression. We cannot bring closure to this communication within the short memory span of a few seconds. Such was the avant-garde style of the 1980s.
But I do not mean to suggest in this chapter that my exposure of the myth of simultaneity should induce us to stick to pie charts and bar graphs. We should certainly use these un-fancy methods when they are the most effective ones. No, my aim is somewhat more subtle: when we are designing an infographic with many different elements, we should make sure that each one resides comfortably inside the four-second window, and leaves us with an impression of organized knowledge rather than a jumble. I am suggesting that a theory of design based on the idea that pictorial representations are more immediate than verbal or numerical ones is a scientifically mistaken theory. Quite often the contrary is the case.

Take this comparison of an infographic from Microsoft, and the home page of the New York Times (Fig. 24):

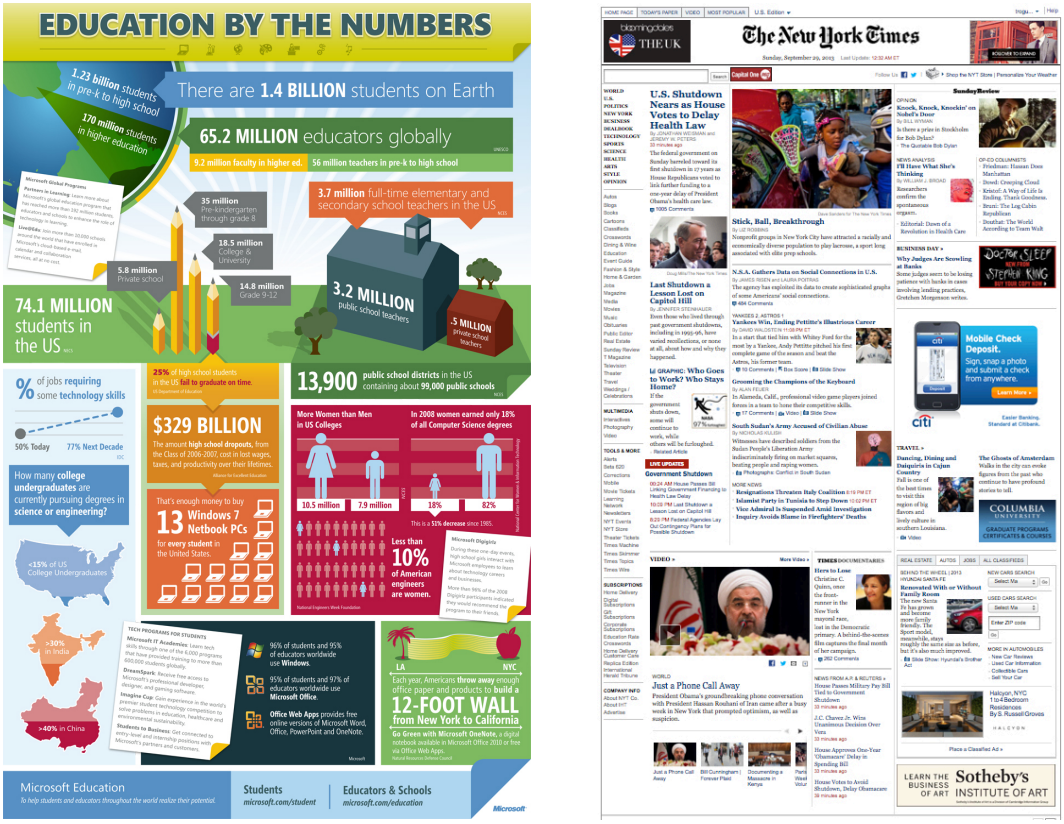


Figure 24: Left: Education by the numbers infographic, Microsoft. Right: The New York Times home page, September 30, 2013.

The Microsoft image could be described as a post-modern descendant of the 1988 art-school poster presented as a scientific organization of facts and numbers. Like the school poster it suffers from lack of closure and also lack of hierarchy in the elements. It aims to give a snapshot of a complex issue (education in the world) within the confines of a single large page. This can certainly be done. But the busy layout, the many colors used, and the too fragmented arrangement, fail to guide us through a definite path. Look closely and you will see all those little Neurathian people still forming obstacles to understanding and to closure.

The New York Times home page, by contrast, has even more information, but does not confuse or leave a memory of jumble. The designers understand that sentences, and not individual words, are what constitute "items," that words can be grouped in lists, and sentences can be grouped in menus, that a title, a subtitle, a picture, a caption, and a paragraph can make up a story. In other words, the designers understand that a few elements together form a "chunk", and a group of "chunks" can be seen as a larger, single item, such as the home page itself.

***

As Daniel Willingham has pointed out, our minds work best when we don't have to think and process, when we simply recall. Remembering a pie is much easier than counting all our marbles again and again. Counting marbles is rather boring and uncreative unless there is

simply nothing else to do. And if we have nothing else to do, the "four-second" window can safely stretch to whatever time is needed:

Figure 25: Baloocartoons, www.toonpool.com/cartoons, 2011.

Chapter 4

The Myth of Universality

In psychology and anthropology, there's an ongoing debate about cross-cultural universals. For several decades after 1945, there has been an intensive search for a such universals, building on the work of linguists (Chomsky), anthropologists (Levi-Strauss), psychologists (Steven Pinker). Some of this work – summarized by Pinker in *The Blank Slate* -- is highly persuasive.

But it has little relevance for the practice of effective graphic design for the following reason: Although there may be universal human traits, *there is little evidence that there are universal graphic representations of them*. While the gestalt psychologists may have discovered universally pleasing shapes like the circle or the square, but they did not show that those form-universals are allied with any particular content-universals.

Here are some so-called "universal symbols" you can order from Shutterstock:

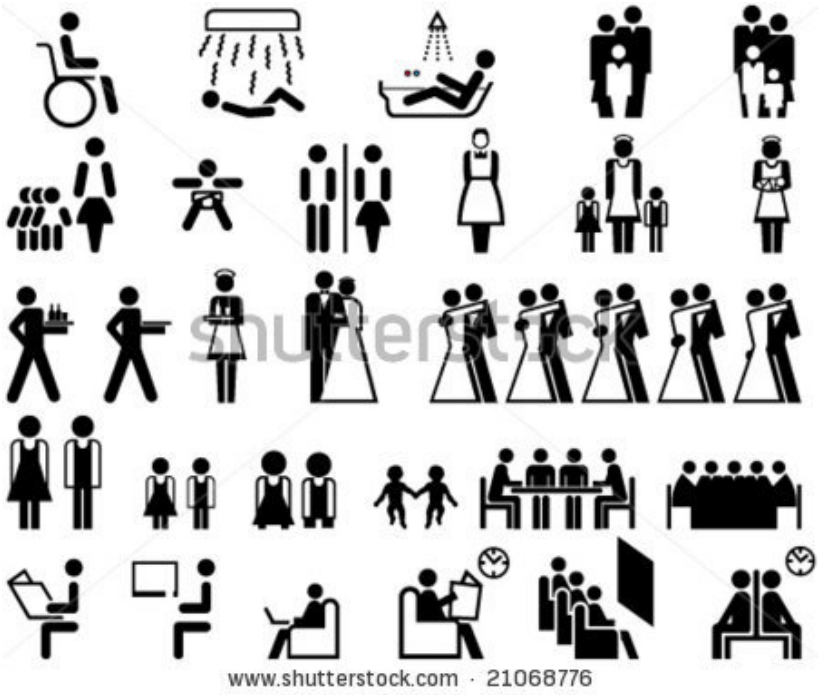


Figure 26: "Universal symbols" you can order from Shutterstock.

The dancing-couple series is especially interesting. His right hand gradually moves from her shoulder to her back, her lower back, to her waist, to her buttocks. Or is it just 5 different couples dancing?

Let's assume we found these Shutterstock images on the walls of a 33-thousand year-old cave. We'd know that a practical joke was being played. We'd know that the stylized manner belongs to the last 100 years. The splayed-out figure (#7) – arms straight out, legs going through some kind of ring would be incomprehensible the invention of the protective child chair in 1875. Or is this just a restroom symbol for an infant changing table?

Olympic pictograms, which standardize the look of the different sport disciplines so that they are understood across different languages, are a good example of change reflecting not so much an historical point of view but rather a geographic and cultural identity. Since the 1964 Tokyo games, which where the first to utilize an organized system of symbols and graphic standards, Olympic pictograms have been an interesting reflection of the national character of the organizing countries, though aesthetically the results have been somewhat mixed. Aside from artistic merit, the stylistic variety of the pictograms confirms that a wide range of formal variation is possible without affecting the general efficiency of the communication, provided that the proper context always be given: sports, Olympics, etc. And so we can recognize the various sport symbols whether the look of the stick figures is rigid and geometric like at Munich in 1968 or fluid and organic like in China in 2008.

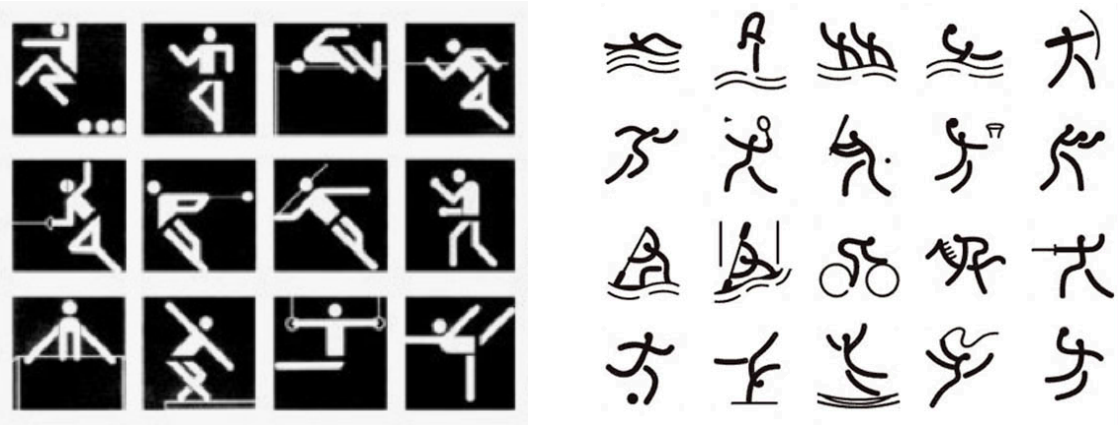


Figure 27: Olympic pictograms: Munich, Germany 1968 and China 2008.

This variability of form and meaning is a key theme in the seminal work of Ernst Gombrich – especially in *Art and Illusion* and *Symbolic Images*. Gombrich makes the point that forms themselves cannot be culture-free universals, because *the form as such does not "take shape" in our minds until after its quasi-representational character has been interpreted*.
Gombrich's insight has its analogue in Wilfred Sellars work on philosophy, which he called the "myth of the given." Nothing is "given" in visual perception. What is seen as given is always-already interpreted.

So if the question about universals is taken to mean: "Is there a universal practical recipe for

creating good graphics," the answer is "no" because of the cultural contingency of any given graphic with respect to any given audience. The visual form of an image is contingent upon its meaning as interpreted by an audience, as the great iconologists (Panofsky, Gombrich, Wind) have shown.

Gombrich, especially, is a useful intellectual forebear of this thesis, because of his profound connection with the findings of modern psychology. He rejected as groundless the idea that certain concrete design elements will appeal to all audiences in all times and places. Gombrich made the point very succinctly in explaining the naiveté of the scientists who put a design (Fig. 28) into the Pioneer Spacecraft meant to communicate something about human civilization for the benefit of beings in outer space who would lack knowledge not only of the represented objects, but also of our conventions of representation (Gombrich 1982). For instance, the right side of the woman's face is narrower than her left. What sort of lopsided creature is that?

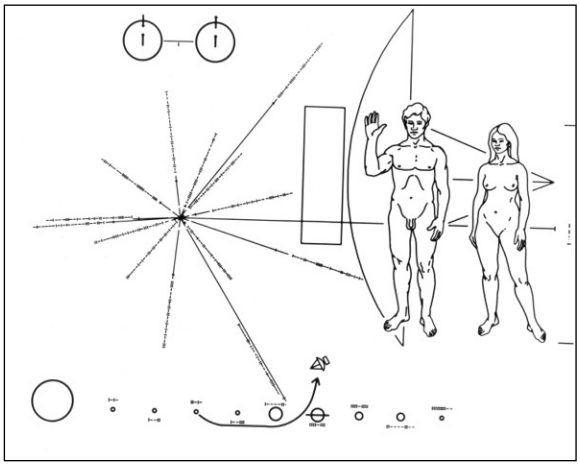


Figure 28: A golden plate with this design was included in the Pioneer 10 Spacecraft launched by NASA in 1972. Source: NASA.

The very form of the design element is never a brute given but it too is a psychological construct quite as much as a verbal interpretation – something co-constructed by viewers out of their prior knowledge and expectations. In contrast to the NASA plaque, this idea can be proven right down here on earth, as is often illustrated by the rabbit-duck phenomenon, also presented by Gombrich in his *Art and Illusion*. (1960: 5)

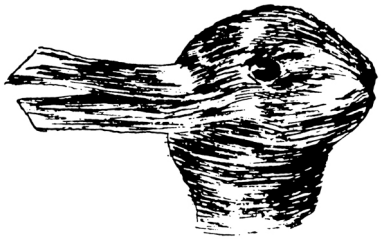


Figure 29: Rabbit or duck? One can perceive one or the other but not both at the same time. Wikimedia Commons, public domain, 2013.

But in the case of the plaque, Gombrich's observation seems so self-evident that one would have imagined NASA scientist to be a bit more logical and not assume anything. But they had a hard time, like most of us would, distancing themselves from the strong cultural and visual conventions of our social group, such as the use of perspective and the choice of the three-quarter view of the woman's face, or the extensive use of diagrams. The plaque will only begin to work if the primary sensory mode of this unknown species happens to be the visual mode, which is by no means guaranteed, and even if aliens see this picture with something like eyes, will they infer what we take for granted based on our human experiences? Will they think that all human beings have short hair if they are male, and long hair if they are female? Will they have and understand gender?

Shared Knowledge and Long Term Memory

In Gombrich's example of the Pioneer plaque, the pictorial elements are presented in a definite spatial arrangement, but all the other meanings -- mankind, gender, space probe, solar system -- are inferred by association. It should be obvious that such associations are possible only in the context of a human, social, cultural, and interpretative body. And that even within this body, specific associations might or might not occur depending on specific cultural sub-contexts. It is pure speculation to assume that these pictorial signs will be interpreted correctly by an alien species, and even fellow humans might not grasp the plaque's intended meaning if they lack the prior knowledge of the concepts of solar system or diagram. In short, there can be no associative relations triggered by the pictures in the absence of past familiarity and prior knowledge with at least some of those pictures. The association with 'solar system' will not occur unless one already possesses some concept of solar system.

In the plaque, it's interesting to note that the designer included pictures and diagrams but omitted written text, on the probable assumption that an alien being would not be familiar with the English language. While it's possible that humans universally share a few archetypical icons, like the face of a smiling baby or a beautiful sunset, the designer's exclusion of text highlights the misconception that a picture is always universal and thus superior to a word. Although it's true that the same thing might be represented in different languages by alien looking words, it's not guaranteed that the same picture will represent the same thing to different people in different cultures.

When the designer regards pictures as superior to words, he mistakenly assumes that pictures always project a given intrinsic meaning that is independent of the viewer. But prior to actual interpretation by a viewer or a reader, pictures are just as meaningless as words because their external form does not, by itself, provide the meaningful content that must already reside, at least in part, in the mind of the interpreter. When pictures are preferred to words because they appear to offer a more fixed meaning that is less open to interpretation, we are assigning to pictorial form an independent life that it does not have, at least not until its corresponding content has been processed by the viewer.

In good design, using a picture instead of a word cannot guarantee universality because pictures and words share the same characteristics of arbitrariness, ambiguity, cultural dependence, variability, and the chance that the meaning of a picture or a word might change

over time. For example, we cannot know from looking at the Pioneer plaque why the man has his arm raised while the woman does not, any more than we can tell if the words "a shot in the dark" are literal or metaphorical. We would need more context and clues, such as additional images or words, speech intonation, etc., to know for sure if they mean "a loud noise in the middle of the night" or "a futile attempt at something." In other words context – the text before and after the given phrase – is needed to determine the correct meaning. Even more difficult to interpret than a figure of speech is irony, where the meaning might be not just different but completely opposite to what the words actually say.

The visual form of the printed words or pictures – and graphic design often functions at the level of a mute, visual text much as a written text does – by itself is not sufficient to answer such simple questions. But if additional text is added to the original text or if images are added to complement it, then these additions can provide the clues needed to understand the intended meaning. The goal will be to strike a balance between a composition that provides all the information necessary to understand the additional meanings that are not immediately obvious, and at the same time manages to omit many inferred meanings that the reader hopefully already possesses, and still communicate fully despite these omissions.

In the constant back and forth between working memory and long-term memory some form of access to stored knowledge is always required in order to make sense of even purely formal inputs. The false belief in universal trans-historical forms is called "The Myth of the Given." (Sellars, 1956). Every form we perceive is post-perceptum, and dependent on relevant prior knowledge. (Cleveland & McGill, 1984; Casner & Larkin, 1989; Carpenter & Shah, 1998; Cook, 2006; Canham & Hegarty, 2010; Hinze et al, 2013). In the course of viewing a graphic or a picture we do not instantly grasp the whole of the form, yet we achieve closure even when viewing just part of an object, because we know from past experience what sort of thing it is. When we see the image of the side of a house we mentally complete the object even when we do not know what the other sides look like. In this image for working memory, we have in view just a few items, but we make sense of the partial view nonetheless, because our relevant knowledge tells us roughly how the streets and the buildings will continue.

Figure 30: View from apartment window. San Francisco, California, 2013.

This knowledge-based interchange between working memory and long-term memory has enormous consequences for graphic design. In visual interpretation, as in speech, the most

important factor in gaining rapid closure and the ability to gain new knowledge is the amount of relevant knowledge that the viewer already possesses. A visitor from the Middle Ages would not make much sense of the view from the window in Fig. 30.

A viewer who is familiar with the needed background knowledge, will be more likely to quickly understand the visual references in any graphic. Hence one of the trans-formal problems to be solved by a designer is to make sure that the taken-for-granted knowledge needed to understand the graphic is actually shared among the target viewers.

One needs to know at a minimum that the sign depicted in Fig. 6 is not an entry to a theater, say, or to a conservative Jewish prayer service where men and women must be separated. Every designer is acutely aware of the importance of immediate physical context as well as shared cultural context, and their relation to tacit conventions.

Figure 31: Unisex restroom sign. Wikimedia Commons, public domain, 2013.

Genre Conventions

George A. Miller did foundational work in language processing. He once observed that the initial meaning that we posit for the word "shot" will be different, depending on whether the word is used on a golf course, a rifle range, or in a bar. (Miller 1999) His point has sometimes been oversimplified as exhibiting the special problem of homonyms in language – different words having the same sound: sun-son, tail-tale. But his point was far more general. All words, like all visual images, are potentially polysemic, a feature of language that enables us to convey an almost unlimited number of nuanced meanings. A certain kind of context makes likely a certain kind of meaning for images as well as for words – the meanings that are usual or conventional to that context. Visual images in themselves are not superior to words in communication, as both depend on context for proper interpretation. Visual forms are also polysemic (Cook 2006). Even when 'a picture is worth a thousand words', the viewer's interpretation will be influenced but which words she already knows.

Different contexts: a golf course, a rifle range, a bar – all carry different conventions and meaning-expectations. The sentence "You're a smart guy." will have quite different overtones as praise or as a put-down. To communicate the desired meaning one has to make known which of the two genres, or contexts, or conventions is being assumed. From this we see that the terms convention, context, and genre are deeply interconnected concepts that converge on the same function. They help reduce ambiguity. And all of these interconnected terms:

genre, convention, and context have in common the assumption of prior relevant knowledge on the part of the viewer.

In an important book, Cognition and Categorization, (Rosch & Lloyd, 1978) Eleanor Rosch and other researchers give scientific support to the principle that type-classification is necessary to making sense of a perception. An overarching sense of the kind of whole we are seeing piecemeal through our momentary window of working memory is necessary to restrict the polysemy of words or images and make ongoing sense of the parts. Hence the close connections in visual and verbal communications among context, convention, and genre. The context (the golf course) suggests a genre (a golf shot, not a whiskey shot) and the connection between the word shot and the actual thing is a cultural convention.

The prior knowledge that influences our present perception is thus just as important to the effectiveness of design as the stringent temporal bottleneck of working memory, and greatly helps overcome that bottleneck. The more quickly accessible that relevant knowledge is, the more rapidly closure can be achieved. Cognitive scientists therefore lay great stress on the concept of accessibility. (van der Helm & Leeuwenberg, 1991) It's up to the designer to invoke quickly accessible, that is, familiar, knowledge among the target viewers. While neither the designer nor the reader can modify the general time limitation of working memory, both can employ strategies to minimize its effects and maximize communication by adding enough familiar elements to provide accessible scaffolding that aids the viewing or learning process – titles, captions, labels, etc. – so that the material is interesting and challenging, but still approachable to the viewer. Amanda Cox, graphics editor of The New York Times, has termed this type of accessible scaffolding the annotation layer of a graphic. (Cox, 2012)

An anatomical sketch by Leonardo da Vinci (Fig. 32) shows just how important this annotation layer is, even when the graphic is not intended for public viewing. Leonardo no doubt understood the limitations of his own memory and made sure to record his immediate observations in a more permanent way.

Figure 32: Leonardo da Vinci, Studies of embryos, c.1510-13. Pen over red chalk. Dim. 30.5 x 20 cm (12 x 8 inches). Royal Library, Windsor Castle, UK. Wikimedia Commons, public domain, 2013.

In sum, the constructive dimension of perception – the relevant knowledge in long-term memory that influences our present perception – is just as important as the stringent temporal bottleneck of working memory, and is the chief means of overcoming that bottleneck. *While neither the designer nor the reader can modify the general time limitation of working memory, they can employ knowledge-based strategies to minimize its effects and maximize speed of communication*. A chief element of effective graphic design is summed up in that sentence.

These considerations can be reduced to three principles about universality:

- Visual forms are not brute givens, but depend on context and interpretation before they become definite visual forms.
- There may be universally pleasing forms, but these are not reliably associated with any particular transcultural meanings.
- There may be universal human traits, but these are not reliably associated with any particular visual forms.

In short, the perception of any graphic is not a reliable given outside of a highly particularized cultural context. Only this context gives the graphic its meaning and its shape. For the graphic designer therefore, freed from the trammels of the fruitless structuralist search for universal visual communication, the problem becomes: "What do I need to do to solve this particular problem of communication in this particular case? I have transcultural and even aesthetic universals in my armory, but I know that their effective application may be very different depending on the particular context and target audience."

This principle will be developed in the next chapter: "The Designer as Iconographer."

Chapter 5

The Designer as Iconographer

Oversimplifications are highly useful to practical crafts. My contrast between the abstract formalism of the structuralists and the culture-ridden interpretations of art by the iconographers is no doubt a reductive simplification of the rich and subtle analyses of the best art historians and critics in both camps. But the empirical evidence favors the emphases of iconographers-– those who stress the interpretive content of images as determinant of their form. Just as in language, where the formal relationships between words depend on a prior interpretation of their meaning – following upon a preliminary generic sense of the whole utterance-- so in pictorial representation – and especially in pictorial representation combined with words – the formal character of a graphic helps foster communication only *after* its general meaning is perceived in a preliminary way, and understood by the viewer.

That is why Saussure's brilliant observations about the phonological structure of language as being a formal system of binary differences – the central doctrine of structuralism -- has been so misleading when applied to meaning. The "system of differences" and the "binary oppositions" that define the phonemic system do not in actual fact describe the system of meanings in language. Those meanings depend as much upon unspoken external contexts as upon the sequence of words. Hence the structuralist practice known as "stylistics" which attempts to derive meaning from linguistic form has been a failure, and has quietly faded away. The form of a text is not disclosed until after meaning has been understood. A simple example: the same sequence of words can be understood straight or ironically; hence the "same" text from the standpoint of stylistics can have very different actual forms. The same difficulty undercuts the program of semiotics, the formal approach to visual art which aimed to organize and explain the so-called system of signs and its structure. A graphic that is understood by its audience might seem well-designed and formally simple. That same graphic, not understood might seem to have a form that is a confused jumble.

Despite these weaknesses, structuralism has provided a neat template for fields as diverse as film criticism, and feminist media studies. The two main reasons for its attractiveness are, first, its connection with the drive to find trans-historical human universals, as I discussed in the last chapter. But, secondly, its strong appeal in recent years has been its (somewhat arbitrary) association with the anti-hierarchy movement of current academic politics. Binary oppositions are egalitarian, or so they seem. Hence they can be understood as helping to overcome of hierarchies such as patriarchy or the dominance of WASP culture. Semiotics levels all. But just as the meaning of a sentence can be straight or ironical, so a binary opposition can support hierarchy or equality equally well. Semiotics, like its literary cousin stylistics, has proved to be a very incomplete and reductionist framework that did not really explain how visual communication works.

Nonetheless, as recently as 2012, the respected designer and author Meredith Davis has attempted, in her ambitious book *Graphic Design Theory,* to use the tenets of Saussure's linguistics and Pierce's semiotics, to explain what supposedly makes a graphic design work. In

an example about book design and page sequencing (Fig. 1) borrowed from *The Structure of the Visual Book* by Keith Smith, she parallels Saussure's syntagmatic dimension of language – its sequential character – with what she terms the "diachronic structure of graphic design". (This is, by the way, a misuse of Saussure's term "diachronic" which he contrasted with "synchronic" as applied to the history of *langue*. His contrast with the sequential term "syntagmatic" is the non-sequential term "associative" and sometimes "paradigmatic" as in the paradigm of verb forms in an inflected language.)

It's curious that Davis chose to represent the unfolding of a graphic design by the example of a book. While this object is obviously a good candidate for making out parallels between language and design, it is rather simplistic to equate a sequence of words in a sentence to a sequence of pages in a book. The first layout in her example below purports to show an absence of "pacing," caused by a repetitive use of the layout, while the other, better example is supposed to show a more meaningful sequence which allows for jumping back in the sequence, an operation the author terms "recollection". While the second layout is supposedly better at allowing this more dynamic reading, the claim is never adequately defended. For both sequences could be "recollected" if we were to view the actual books with their real texts and photographs. The claim that the second allows recollection and the first does not is simply not the case. Characteristically, then, the formalistic approach borrowed from structuralism quickly falls apart in the face of empirical observation.

No doubt Saussure's syntagmatic relations between the words in a sentence could be stand in for a storyboard of the sequential printed pages of a book, but such parallelism is suspect and monocular. Speech and visual pacing are too complex to be so easily correlated. It's true that words and images both share similar characteristics of ambiguity and polysemy, but those are the very characteristics that explain why structuralism doesn't work. Formal elements will always be dependent on and embodied with interpretation. Every form is meaningless until it has been interpreted. Meaning changes the form, as the rabbit-duck phenomenon shows. As the Italian designer Bruno Munari put it concisely: "everyone sees what they know."

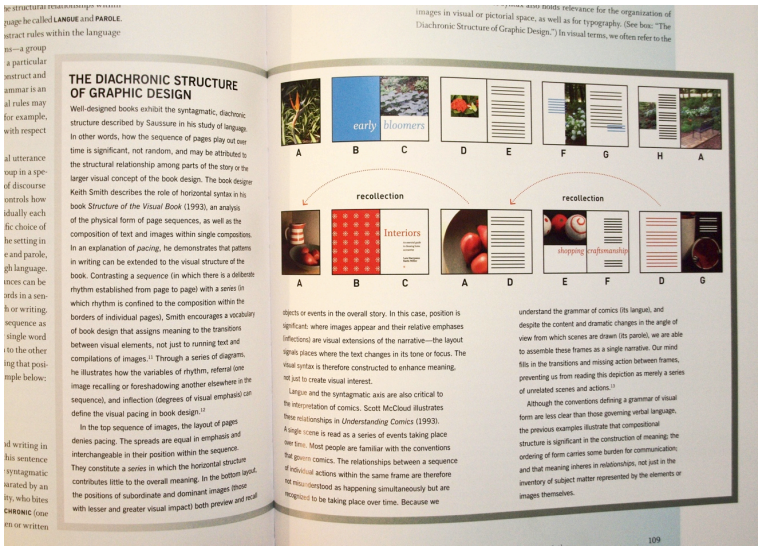


Figure 33: The Diachronic Structure of Graphic Design, 2013. Meredith Davis. In Graphic Design Theory.

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Humans have a tendency to see meaningful shapes all around them, and often construct meaning – sometimes culturally conditioned, sometimes not -- out of meaningless forms and patterns. Just as Leonardo could marvel at the myriad forms and shapes that clouds could offer an imaginative person, so mortals of the 21st century can spot things and see cool shapes in familiar and unfamiliar places, whether those shapes are intentionally speaking to us or not. Here's a culturally universal example: We see human faces everywhere, from the electrical outlet in the wall to old-fashioned hot and cold water faucets in the sink, to a simple house facade with two windows and a door. Freud would point out the tendency of humans to see phallic symbols everywhere.

And designers, being very visual, sometime see more than is really there to be seen by ordinary viewers. For some Western designers at least, everything in our surroundings turns into a letter of the alphabet. Football goalposts make the letter "H". Open scissors become a letter "X". A funnel is a letter "Y", and so on. Once you turn on this mode of letter recognition, the game of seeing them everywhere can become quite fun and entertaining. But it can also lead to one of the most common mistakes that a designer can make. Not everybody thinks like a designer. This blind faith in form often can lead to surprising and undesired results when the meaning that we originally intended for a particular form or shape does not register with an intended audience and the communication is compromised.

Most viewers rarely assign meaning to formal elements until they have been contextualized by the methods and intentions of the designer. The form in a graphic design piece is more or less meaningful depending on the cultural match with viewers, who will see and read a good portion of the intended meaning as a function of what they have already seen or read. A graphic can never speak for itself. It is mute, and many of its implicit meanings must be carefully weighed by the designer in order for a match to occur between the graphic and the viewer. And so *a picture that is worth a thousand words is really worth only those few or many words which the viewer already knows*. All communication processes happen within specific cultural settings, and therefore each graphic will have to be de-facto, ad hoc constructions, much in tune with local idioms and conventions, and also mindful of the viewer's prior knowledge or lack thereof. Even though the graphic does not know how to talk, we can, and should, supply it with sufficient visual and verbal provisions that will help it survive the journey towards meaningful communication.

The need for the new:

When the designer neglects the social dimension of visual and verbal communication the result is likely be a confusing or misleading graphic. But how much in a graphic should be novel and how much should be familiar? This of course depends of the specific context, and so the graphic construction has to be, perforce, an ad hoc construction that marries known elements with novel material. The relative proportion of the two will likely depend on the sophistication and preparedness of the intended audience. In the solar system example, when I mentioned Saturn's rings, I assumed that the reader was familiar with this unique characteristic of this particular planet. At a more basic level, I assumed that the reader already knew the meaning of

the word ‘ring’: a circular object wrapped around another object. The deeper we go into the discussion, the more difficult it is to define the limits of the discussion because each new definition introduces additional words and concepts. But the more words and shared concepts and pictures the viewer or reader already knows, the fewer the levels of explanations that are needed and the quicker the understanding of the original intended meaning of the written text or visual composition.

If background knowledge and familiarity and are so important, how can designers reconcile these constraints with the demand to constantly produce fresh, new, and innovative work? How can designers find ways to hit that sweet spot between what is too familiar, maybe uninspired and therefore boring, and that which is hyper-new and radical and could get panned or misunderstood? Just as teachers need to find a sweet spot in the presentation of new material to students, and make a presentation that is neither too simple and boring or too difficult and discouraging, so in the same way the designer needs to present the right amount of information in a way that is both pleasing and intriguing. This material has to be somewhat familiar and yet momentarily challenging, to help insure that at the end of the process the viewer will come away with additional new and lasting knowledge.

Handbook

Rules You Can Use

Pino Trogu

Small Handbook of Information Design: 16 Principles for Better Data Visualizations.

Every graphic is an ad hoc construction, therefore these rules can be broken depending on the context. However you should try to do the graphic by following these rules first and break them later if necessary.

San Francisco State University
College of Liberal and Creative Arts
Department of Design and Industry

DAI 523 Information Design 1: Data Visualization
Fall 2013

Small Handbook of Information Design: 16 Principles for Better Data Visualizations.

01 Use pencil and paper.
02 Content is first.
03 Do not draw graphs by hand.
04 Do not enlarge numbers.
05 Use words, not just images.
06 Use small multiples.
07 Do not bungle the meaning.
08 Do not create op-art.
09 Do not use little dots for numbers.
10 Do not use colors (to be memorized).
11 Sort by value, not category.
12 Equally space time intervals in timelines.
13 Avoid meaningless concept maps.
14 You can use small type.
15 Do not screen type.
16 Psychology of perception.

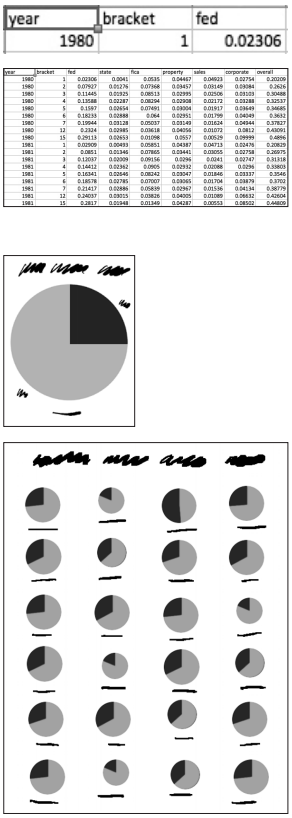
For more copies of this booklet: **http://bit.ly/1bhDU4y**
Some of these principles are based in part on Edward Tufte's books and workshops.
For more info visit: www.edwardtufte.com
Thanks (and apologies) to my students for showing details from their various projects.

Notes:

01 Use pencil and paper.

In the early and later phases of a project, simply use pencil and paper as your design tools, use graph paper if needed, to sketch ideas, try out designs, and work out your proposal. Work on your ideas and your concepts by sketching your visualizations. Solve problems through sketching by hand, not by staring at a computer screen.

02 Content is first.

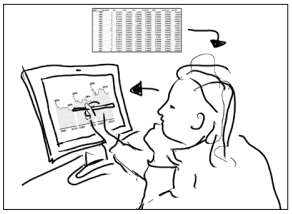


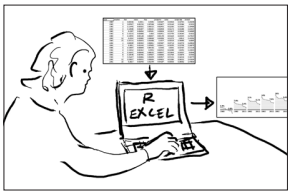
year	bracket	fed
1980	1	0.02306

year	bracket	fed	state	fica	property	sales	corporate	overall
1980	1	0.02306	0.0041	0.0535	0.04467	0.04923	0.02754	0.20209
1980	2	0.07927	0.01174	0.07568	0.03457	0.05149	0.03094	0.2624
1980	3	0.11445	0.01925	0.08513	0.02995	0.05206	0.03103	0.30488
1980	4	0.13588	0.02287	0.08294	0.02908	0.05172	0.03288	0.32537
1980	5	0.1597	0.02654	0.07691	0.03004	0.05357	0.03649	0.34665
1980	6	0.18233	0.02888	0.064	0.02951	0.01799	0.04049	0.3632
1980	7	0.19944	0.03128	0.05037	0.03149	0.01624	0.04344	0.37827
1980	12	0.2324	0.02985	0.03618	0.04056	0.01072	0.0812	0.43091
1980	15	0.25113	0.02653	0.01098	0.0557	0.00529	0.09999	0.4896
1981	1	0.02909	0.00493	0.05851	0.04387	0.04713	0.02476	0.20829
1981	2	0.0851	0.01346	0.07865	0.03441	0.05055	0.02758	0.26975
1981	3	0.12037	0.02009	0.09156	0.0296	0.0241	0.02747	0.31318
1981	4	0.14412	0.02362	0.0905	0.02932	0.02088	0.0296	0.35653
1981	5	0.16341	0.02646	0.08242	0.03047	0.01846	0.03337	0.3546
1981	6	0.18578	0.02785	0.07007	0.03065	0.01704	0.03879	0.3702
1981	7	0.21417	0.02886	0.05839	0.02967	0.01536	0.04134	0.38779
1981	12	0.24037	0.03015	0.03826	0.04005	0.01089	0.06632	0.43604
1981	15	0.2817	0.02948	0.01349	0.04287	0.00553	0.08502	0.44809

Content is first, form is second. Select interesting content. Content-less stuff produces form-less, uninformative visualizations. This means that you need one or more data sets that are rich with data. Many columns and many rows (lots of data points) are better than just two data points. For example, two percentages: 25 and 75 are in themselves not very interesting and it would be hard to pull off an interesting visualization based on just those two numbers.

03 Do not draw graphs by hand.

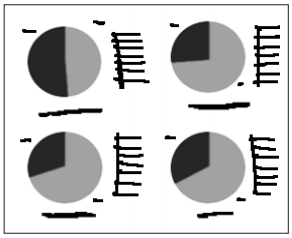




Do not take a numerical table or spreadsheet and then render the shapes (the bars, the lines) by hand, even if you're using Illustrator. Rather, take the data set and process it through a data visualization program, such as R, Excel, or other. Then bring the file into Illustrator to clean up and fine-tune line weights, typography, color, etc.

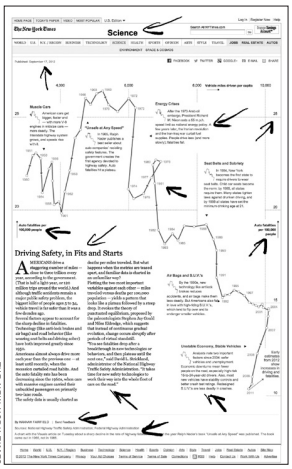
04 Do not enlarge numbers.

55% BLA BLA BLA
27% BLA BLA BLA
30% BLA BLA BLA
35% BLA BLA BLA



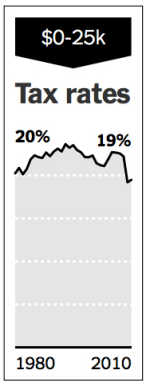
Do not turn data points into stand-alone enlarged numbers with a percentage sign next to them to make them look important. Filling up your visualization with such “visuals” is not any better, and might in fact be worse, than just having plain text, with no “visualizations” at all. An infographic is not a PowerPoint template. The best thing to do is to combine words and images together.

05 Use words, not just images.

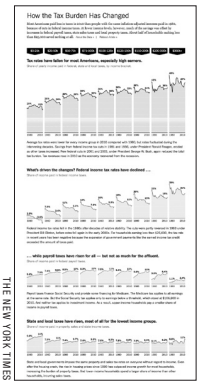


Use sentences: subject, verb, object. Close your clauses. Set up an introduction and follow through with visualizations. Use a title, a subtitle, an introduction, main text if needed, labels, captions, credits (for pictures) call-outs, footnotes, sources (for data sets), and a signature (colophon). This is called “the annotation layer”. Plus, you can include numerical tables, if needed and appropriate, within the visualization.

06 Use small multiples.

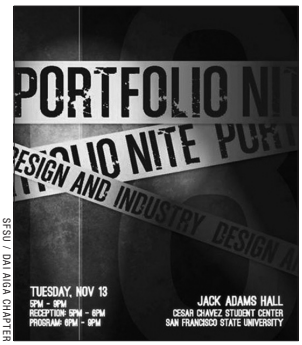


Content is king. One single blown-up graphic is not so good, especially if it's just showing very few data points. Don't be stingy. For example, a pie chart showing 25 and 75 percent and filling up a whole poster is not so good. It's much better to have a high number of elements even if they're small, like in a geographic map. Twenty little pies are better than one giant pie. Ten little line graphs are better than a single giant line graph.



THE NEW YORK TIMES

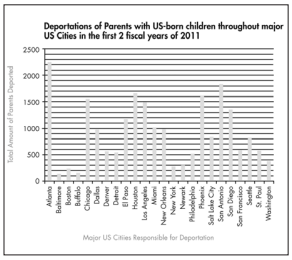
07 Do not bungle the meaning.

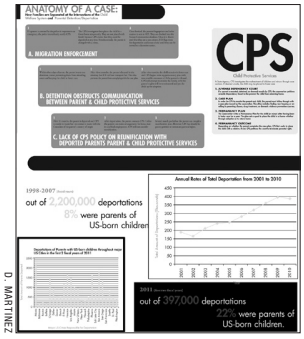


SFSU / DAI AIGA CHAPTER

Do not bungle the meaning of your visualization. Say what you mean and do not confuse the reader, starting with your opening title and subtitle. This applies to choice of words as well as pictures. For example, if the topic is "Tuition fee increases" do not say: "Fee hikes on Mount Everest"; say instead: "Fee increases reach new high". If the topic is "Black Friday (shopping)", do not say: "Products cheap as a black sheep"; say instead: "Black Friday keeps more green in your wallet". If the topic is "Christmas shopping", do not say: "Christmas shoppers pray to God for bigger discounts"; say instead: "Consumerism and religion mix in traditional Christmas holiday". Do not play loosely with irony and puns, and don't mix-up your metaphors.

08 Do not create op-art.

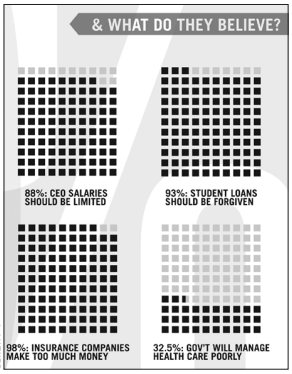




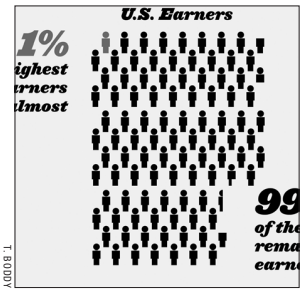
D. MARTINEZ

Do not make op-art (optical art) effects by using bold condensed sans-serif fonts where the strokes are the same width as the counters in the font and also the width of the spacing between the letters. This creates a very annoying, vibrating checkerboard effect. Do not use solid backgrounds, boxes, thick borders, or arbitrary bold type. If you are using solid backgrounds throughout, invert the whole image to see if it's better with the opposite values. On a Mac, use control-option-command-8 to instantly invert the colors of your screen on the computer. See if it would be better the other way around (black type on white background). If nothing is gained by the solid fills, then get rid of them.

09 Do not use little dots for numbers.



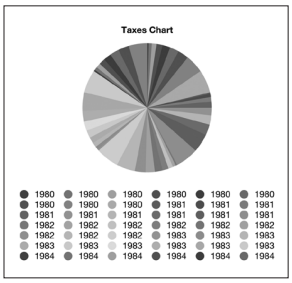
J. LUTHER



T. BOODY

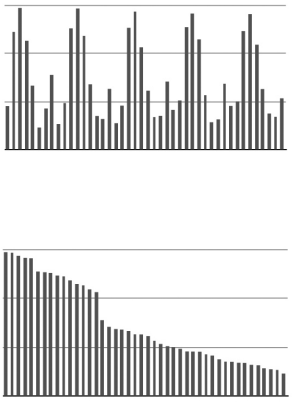
Do not use little dots for percentages. Do not use little people for quantities. Do not visualize quantities by the endless repetition of single units like little dots or little squares. We don't use pebbles to count anymore, and we have invented a tool called "place value". It's better to write out the number or to visualize it using a single solid area, not many tiny areas in little rows. Do not use little people as units to show quantities, even if the quantities represent people. Think of those poor little guys whose limbs get mutilated when you have to represent a fraction: arms, legs, even heads get cut off without mercy!

10 Do not use colors (to be memorized).



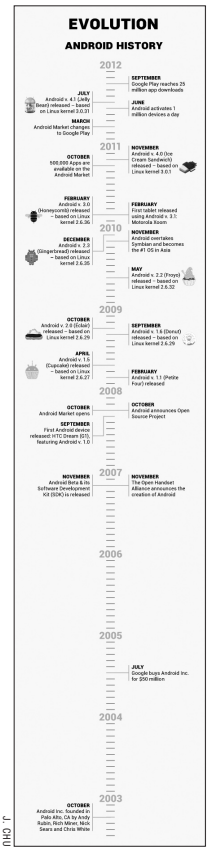
Do not use colors if the reader has to memorize them. Do not use colors if you have to have a legend for every single color in order to understand the graphic. If no legend is required, then little thinking is needed in order to perceive the graphic. Too many colors in the graph take a huge toll on the attention capacity of the reader. One cannot remember all those colors because we can only remember a small set of things at once: five-seven. Also, colors do not have an intrinsic order, therefore they should not be used to sort things, unless you use value as well: darker color for more, lighter color for less, both being from the same hue or two diverging hues maximum.

11 Sort by value, not category.



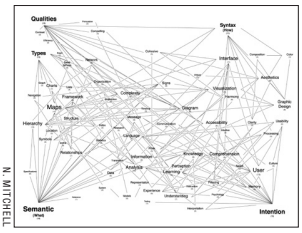
Sort by performance (value), not alphabetically. When part of the information is categorical but includes values for each category, do not sort the categories alphabetically. Instead, sort by the values for each of those categories. For example if the categories are products or states and each is a value, sort by the value, not by the alphabetical names of the states or the names of the products.

12 Equally space time intervals in timelines.



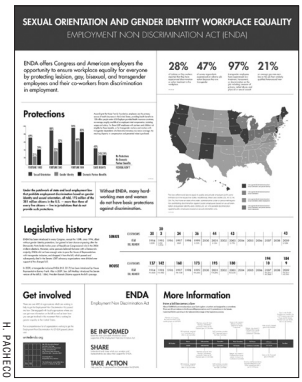
Keep the spacing equal (for equal periods of time) even if that results in big information gaps within certain periods of time. Gaps are as meaningful as periods of concentrated activity. When data is concentrated within a few years, use typography and other means to make everything readable while keeping the temporal spacing even and correct.

13 Avoid meaningless concept maps.



Avoid meaningless concept maps and network graphs. For a simple reason: they include on the page too many items and abstract concepts at once. Our working memory (short-term memory) allows us to hold in memory only a few items (4-7) for a very short time (2-4 seconds) before we have to move on. Concept maps look very cool but they are also very uninformative and little information is retained from them in our long-term memory. Generally, the thing one remembers from them is their vague visual form – the shape of the graph – rather than the more important subject matter.

14 You can use small type.



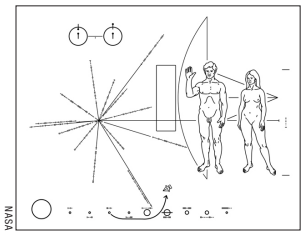
H. PAGHE6D

You can use small type in a big poster. Use as many sizes as needed. A range from 16-18pt to 24pt is the best size range for most text on a poster, excluding the main title and possibly the subtitle, with even smaller sizes for captions and labels. For short texts, use 24pt. Sometimes 30pt for larger text can be used. In general, imagine that you're standing 20 to 30 inches from the poster. At this distance, you should be able to read most text elements in the layout.

15 Do not screen type.

Every font is a wonderful and beautiful universe unto itself. Do we really need to tinker with what is already a very sophisticated sign system? Do not reverse, screen (make tints), border, condense or expand type. Do not italicize type by pressing the "oblique" button. Use a font that already has a wide range of weights. Traditional old-style italic fonts are best to save space if needed, as they are naturally condensed and were designed for this purpose. Do not let your text lines run longer than two-and-a-half times the alphabet – about 60 characters. Break up the big text boxes into two or more columns whenever necessary so that your measure (box width) is "measured" and correct. Do not justify text if possible, use flush left / ragged right (FL/RR).

16 Psychology of perception.



Be aware of the following terms related to cognitive psychology and psychology of perception: working memory, co-construction of meaning, background knowledge, conventions of representation, cultural (visual and verbal) conventions, context, genre, the annotation layer, closure.

For more information about the terms above, read my two papers:
The Four-Second Window
http://bit.ly/Ve2mph
and
The Double Constraints of Convention and Cognition in Successful Graphic Design
http://bit.ly/12zLinL
Visit URLs to download the PDFs of the articles.

Notes: