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Information Design 3

Image Design

Revised edition 2015

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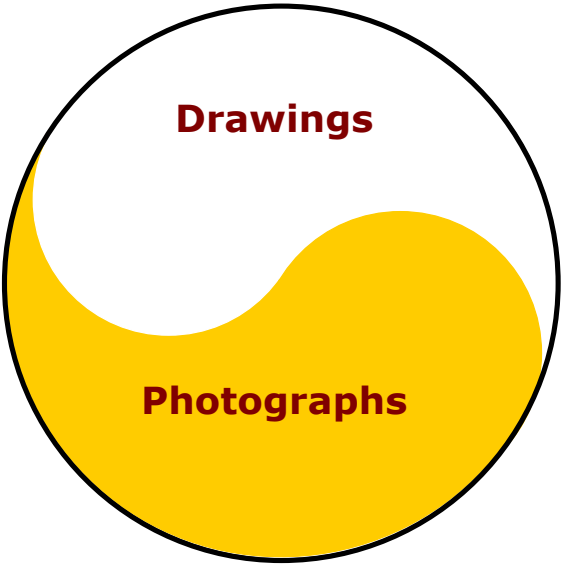
Information Design 3

Image Design



Rune Pettersson * Institute for infology

Information Design 3–Image Design

Yin and yang, or yin-yang, is a concept used in Chinese philosophy to describe how seemingly opposite forces are interconnected and interdependent, and how they give rise to each other. Many natural dualities, such as life and death, light and dark, are thought of as physical manifestations of the concept. Yin and yang can also be thought of as complementary forces interacting to form a dynamic system in which the whole is greater than the parts. In information design, theory and practice is an example where *the whole is greater than the parts*.

In this book drawings and photos are my own, unless other information.

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Tullinge 2015

Preface

Information design is a multi-disciplinary, multi-dimensional, and worldwide consideration with influences from areas such as language, art and aesthetics, information, communication, behaviour and cognition, business and law, as well as media production technologies.

Since my retirement I have edited and revised sections of my earlier books, conference papers and reports about information design, message design, visual communication and visual literacy. The result is this series of six books:

Information Design 1–Message Design
Information Design 2–Text Design
Information Design 3–Image Design
Information Design 4–Graphic Design
Information Design 5–Cognition
Information Design 6–Predecessors & Pioneers

These books include definitions, selected results from research, theoretical considerations, as well as practical guidelines for message design. The intended reader is especially interested in research and theory related to message design, and the design of information materials and information sets.

Tullinge, Sweden
Rune Pettersson, Ph.D.
Retired Professor of Information Design

Contents

Visual language

It has probably always been natural for Man to express himself or herself by means of visual messages. Since the beginning of mankind we have been using body languages and different kinds of signs for communication. Prehistoric Man made murals and rock inscriptions with mythological meaning. In everyday life, people probably made drawings on the ground to show the location of game for their food. Simplified images ultimately evolved into characters, letters, and numerals. Pictures helped Man communicate long before we had written languages for our messages. Our children make pictures, they draw and paint long before they learn to read and write.

For 30,000 years we have had murals. For about 4,000 years we have had rock inscriptions. For about 700 years we have had framed paintings and put them on our walls as pieces of art. For more than 500 years we have had printed illustrations in books. We have had photos for more than 150 years, films for 100 years, electronic pictures for 50 years, and computer images for more than 25 years. Electronic "live-pictures" last only for one twenty-fifth of a second, but they can be stored for example on videotape or videodisc. Nowadays, pictures are to be found almost everywhere. They differ in character. It is not possible for every one to stand out on every occasion. People "drown" in a flood of general "pictorial noise," a kind of mental pollution of the environment.

Visuals can be classified according to several different criteria, such as sender, receiver, content, execution, format, and context, and even according to criteria such as function, use, and the means of production. Thus, there are many possibilities

for classification. However, one and the same visual can and will be classified in different ways at the same time, depending on the criteria applied in each case.

Visual languages differ just as do spoken and written languages. The codes used in visual language differ in different cultures as well as in many sub-cultures. Even within a western mass-media country like the U.S., visual codes differ in different parts of the country, in different socioeconomic groups, etc.

Visual languages have their own "grammars," syntaxes, etc., just like spoken and written languages. In verbal languages, *syntax* is the study of the rules for combining words into grammatical phrases, clauses, sentences and paragraphs. In visual languages, *syntax* depends upon the spatial arrangements of the visual elements on a page (Horn, 1998, p. 75). Our ideas about good arrangements depend on how our perceptual system works. Our ideas about good arrangements depend on how our perceptual system works. Many ideas are best expressed by visual language, and others can only be expressed by visual language (Horn, 1999, p. 28).

Griffin, Pettersson, Semali, and Takakuwa (1994) found that "cultural differences" was the predominant variable when symbol understanding was measured. An international symbol system based on intuitive interpretation of symbol meanings may not be possible until the world shares a common culture. Visuals are cultural products shared by individuals (Griffin et al., 1995; Moriarty and Rohe, 1992) as such, they are understood within individual people's frames of reference (Kovalik, 2005; Singer, 2010).

Visual messages are superior to verbal messages when content is emotional, holistic, immediate, spatial and visual

(Boeren, 1994; Brouwer, 1995; Hugo, 1996). Meaning is immediately apparent on a basic level, but the visual language must be learned for true comprehension (Barry, 1998; Pettersson, 1993).

To a limited extent, some of the factors involved in the grammar and syntax of visual languages are known. However, most of this linguistic work still remains to be done. One obvious problem is the lack of simple and general systems for classifying visual messages.

Image design is the development and execution of visual messages. It is a powerful form of communication because visual messages stimulate both intellectual and emotional responses–they make us think as well as feel. Image design can be changed a great deal without any major change in the perception of image content. Generally speaking it is not possible to rank the different types of visuals. Often the type of visual that should be used must be determined in each case with a view to demands on the picture and the prevailing budget framework.

Using a large number of visual examples Malamed (2009) offers designers six principles for creating graphics and *visual language* that people may understand. These principles are called 1) Organize for perception. 2) Direct the eyes. 3) Reduce realism. 4) Make the abstract concrete. 5) Clarify complexity. 6) Charge it up.

Levels of meaning in visual language

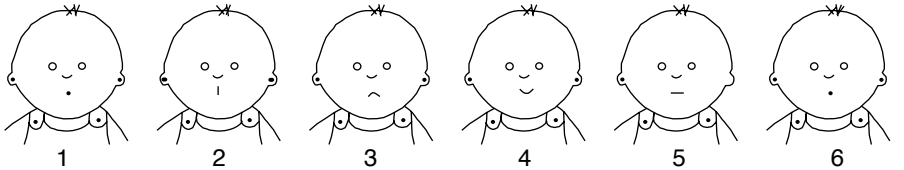
In contrast to spoken and written languages, pictures have no general, distinguishing elements that are not bearers of information. Visual languages have “analogue coding.” Visuals are iconic and they normally resemble the thing they represent.

Basic elements in visual language

The simplest components in a picture, i.e., its *basic elements*, are *dots, lines*, and *areas*. Dots, lines, and areas can be varied and put together in many ways. Changes of the basic elements will result in different images, sometimes of great and sometimes of minor importance. Simple image elements can be rotated, turned upside down, and re-combined to form a series of completely different but still intelligible representations of real concepts. (See the chapter *Execution of visuals*.)

The basic elements are sometimes meaningful, sometimes not. The number of ways in which the smallest image components can be inter-combined is unlimited, and the importance of certain combinations varies from one picture creator to another.

Like written and spoken languages, visual language has varying levels of meaning. In a picture, the 1) basic elements form 2) shapes, that form 3) visual syntagms or sub-meanings. These components interact to form 4) complete meanings in still pictures and moving pictures.



In a pictorial presentation, a dot or a line may have widely varying meanings. Here, execution influences content. To illustrate this, six copies were made of a simple drawing. Figure 1 was left unchanged. The mouth was changed in figures 2–5 by the addition of small lines that completely altered our perception of the illustrations. In Figure 6 a small line was added to the hair, but this addition has no effect on our perception of the content in the illustration.

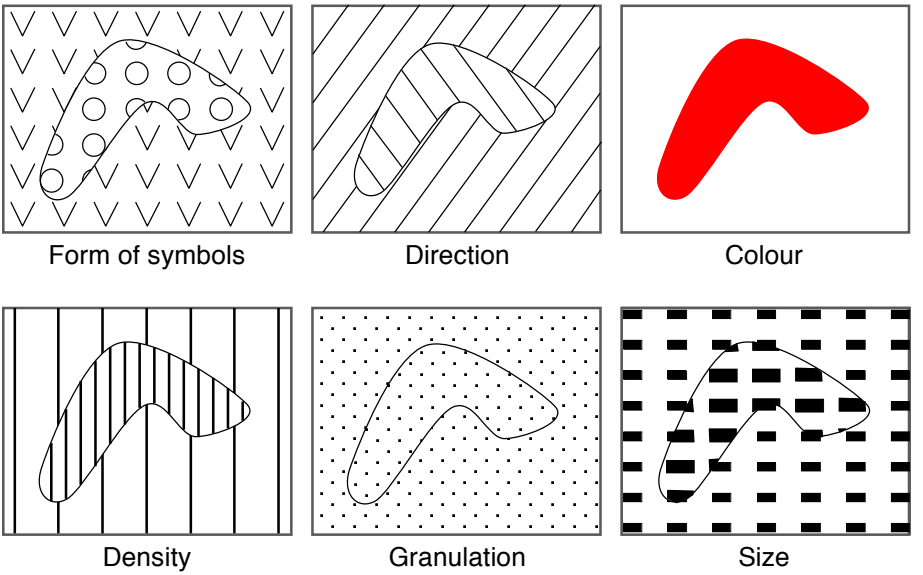
However, Cossette (1982) claimed that it is possible to build an iconic "alphabet." He identified six families of basic graphic sign elements, which he called graphemes, e.g., "visual phonemes." Each of these *graphemic elements* is part of one of six continuum families: *tallness, value, grain, colour, orientation*, and *form*. (As early as 1967 Bertin had discussed the same variables.) Each grapheme signifies nothing in itself. A spot is nothing but a spot. Together with other graphemes the spot may be contextually enriched to a unit of iconic significance, an *iconeme*. In a photograph of a man, one iconeme can be an arm, a leg, the head, and so on. By analysis of an image, it is possible to identify the iconemes that are important to the information content and identify the key syntagm, the "meaning nucleus" of the visual. Editing, eliminating, or adding certain iconemes can alter the effectiveness of an image.

In my view, the basic elements are not equivalent to the phonemes in spoken and written languages. Visual signs do not

retain their meaning in the same way as verbal signs when rotated and turned in different directions. Also, the actual placement on the page, the layout, is important.

In my view, the Cossette graphemes represent qualities more than visual phonemes. Graphemes would instead be dots, lines, and areas, since they all can vary more or less with respect to tallness, value, grain, colour, orientation, and form. Anyhow, they are all variables in the visual language. If there were some kind of "visual phonemes," it would be possible for people to learn to draw and paint in about the same way they learn to read a text.

According to Bertin (1967) and later Baudoiun and Anker (1984), a graphic language used on maps consists of visual variables. The most important variables are position and place, form (of symbols), directions, colour, density (or greyness), granularity (or texture), and size (of symbols). Each variable can be a dot, a line, or an area. The way in which different variables are combined has greater importance than how the variables are comprehended. Using too many visual variables at the same time makes map reading more difficult. When several variables are used simultaneously the hierarchy of visibility is important. The largest symbols are always perceived first. Size is more important than form and colour.



Here are examples of visual variables in the form of areas on a map, based on Bertin (1967), and Baudoiun and Anker (1984).

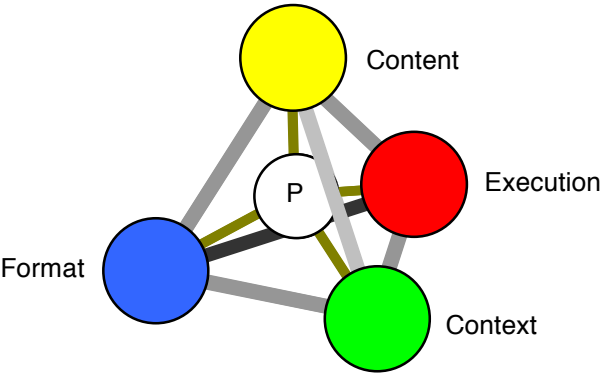
In cartography Stigmar (2010, p. 15–16) used the term *symbol* to describe the visual objects that constitute the map, usually together with descriptive text elements or number labelling. Mijksenaar and Westendorp (1999, p. 5) discussed instructional design and they concluded that the "language of visual instruction" remains very primitive, with a limited number of signs and a weakly developed grammar.

Structure of visual language

The structure of visual language is formed by different image variables that jointly influence our interpretation of images. Image variables can be subdivided into four main categories: content, graphic execution, context, and format.

Variables related to *image content* are the degree of realism, the amount of detail, objects, time, place, space, events such as "action," humour, drama, violence, etc., time displacement, parallel action, metaphoric descriptions (symbolic actions), the relevance and credibility of the contents, comparisons and statistics, motion, sounds such as speech, music, sound effects, and emotions. Some of these variables apply to moving pictures in films or TV. Some apply to stills in printed media like books, newspapers, etc. Others apply to both stills and moving pictures. The contents of pictures can evoke highly positive or negative responses in viewers, especially in children. Visual language can affect our attitudes and emotions more easily than speech and text.

Variables related to an image's *graphic execution*, form, or art style might consist of image factors and image components. They are composed of non-significant image elements, such as dots, lines, and areas in different combinations. Examples of image factors and image components are image type, i.e., whether images are drawings, paintings, photos, computer-generated visuals, etc., brightness, light, shape (external shape, external contour), size (image, subject, depth), colour (hue, value, saturation), contrast, emphasis, composition (organization, centres of interest, balance), perspective (depth, depth-of-field, image angle, image height), technical quality, symbols, signs and code signals in the image, pace, speed change (slow, fast), editing, zooms in and out, panning, visual complexity, and visual effects.



Variables in visual language can be related to content, execution, context, and format. This model illustrates the close relationships of all the different groups of variables. All variables in visual language will influence our perception (P).

A picture has both an internal and an external *context*. I regard factors inside the medium as internal context or inner context. In books internal context is the interplay between text and illustrations, the interplay between illustrations and layout. Movies and TV programs have sound with speech, music, and sound effects plus visual and audio metaphors. Some computer programs contain advanced animation with interaction between text, images, and even sound. I regard the entire communications situation, i.e., senders and their intentions for the picture and receivers and their circumstances (e.g., time available), as external context.

The choice of *format* is of major importance to our perception of image contents. Our perception of a picture (such as a photograph) changes when we view it as a paper print, transparency projected on a white screen, as a computer image, etc. If you watch a film on TV, cable TV, or VCR at home alone, your

perception of the film is very different from your response when you watch the same film on a wide screen with hi-fi sound in a cinema full of people. In analogical technical systems, letters and numerals are represented by defined "type" (a, b, c, ...). Pictures consist of lines and halftone dots. In digital systems, image elements are mathematically defined either as intersections of coordinates and vectors providing direction or as "pixels," i.e., small rectangular image components.

As an example of the interplay between different variables, let us consider an ordinary deck of cards. It consists in fact of 52 (or 54) different visuals. Regardless of the suit, cards with small values, such as one to six, are usually "very easy to read." It only takes one or a few glances for a card player to know which one of the 52 cards he or she has been dealt. Cards with values from seven to 13 contain more information and can be classified as "easy to read." However, pictures of jacks, queens, and kings are sometimes harder to read and distinguish from one another, depending on their design and execution complexity. Cards of the same numeric value, e.g., four, differ in their execution with respect to the symbols for the four suits. They differ in content. Different decks of cards can differ in design and execution. Thus, e.g., the king of spades looks different in different decks, but the king always represents the same content. A card seen together with other cards is seen in different contexts. The value of one card (or of any other visual) is different, then, for the player (or for the user) in different contexts.

Properties of visual language

Spoken and written languages, like text and music, are linear. They must be read (listened to) in a particular sequence to be comprehended. However, visual language is two-, three-, or four-dimensional and can be "read" by letting the eye scan a picture or sculpture in many different ways. Time is an important dimension, not only in film and TV, but also in still pictures. Our "decoding" of an image, and our subsequent perception of it, may vary considerably with respect to which of the visual cues we see first. Studies of eye movements have shown that we often scan pictures in search of simple shapes providing structural simplicity. The brain fills in missing data so a logical and "complete" visual impression is created. Influenced by our reading habits, people in western countries often scan pictures from left to right.

In comparison to a written text, a visual contains an infinite amount of information (Pettersson, 1985). By selecting and utilizing different parts of a picture's information on different occasions, we can experience completely new and different perceptions when we re-see a picture in new contexts. Like other languages, pictures consist of coded messages that are comprehensible in a given social context and in a given age. For example, we often find it difficult to interpret the messages in pictures from unfamiliar cultures and ages. "Modern art" puzzles its public who has not yet learned to decipher the new codes.

The reader (viewer) always has greater freedom in interpreting a visual message than a verbal message. Pictures almost always convey multiple messages. Extraneous messages may compete with the messages the sender regards as significant and important. So pictures always incorporate some ambiguity

and numerous "correct" interpretations, although not always a picture creator's intended or anticipated interpretation. The way in which a picture is interpreted depends to a great extent on the reader's code in relation to the sender's code. Studies of intended vs. perceived image content give clear evidence that there are major differences between intended and perceived image content.

There are many ways to depict even the simplest object. Many pictures are appropriate to and representative of a given designation, such as "Easter," "Christmas," "flowers," "children," "horses," "dogs," "cats," "cards," etc. The depiction of, e.g., "Jesus Christ" and "Buddha" is commonplace in the classical art of the respective religions. The number of pictures capable of depicting a concept declines as the degree of descriptive detail increases. Many pictures may be regarded as "visual synonyms." A message may always be expressed in different pictures. A picture will always be interpreted in different ways. Thus, it may be concluded that pictures used in information and instructional materials always should have captions to guide understanding of the content.

As far as ambiguous pictures are concerned, there is often a major difference between their denotation, i.e., their literal meaning, and their various connotations, i.e., their associative meanings, and their private associations. By, e.g., exaggerating perspective, deforming shapes, making symbolic use of colours, etc., a picture creator can easily create works that evoke extra associations in viewers. This is in fact the very idea behind an artistic picture. However, the informative picture should not be open to different interpretations. The picture's message should

then be the message intended by the person/agency commissioning the picture.

The total amount of information presented varies considerably in different media. A typed A4-sized page can hold up to 2,500 characters, whereas a TV image consists of 250,000 pixels whose colour content and grey scale can be changed 25 times a second. By editing a text we can reduce the number of words required to convey a "message." The amount of information in synthesized (computer-generated) speech can sometimes be reduced by up to 99% without obliteration of message comprehension. A number of graphic elements in pictures can also be reduced without any major impact on content.

We can delete, add, or relocate data and information. Graphic elements that constitute boundaries between different image elements are more important to our perception of the image than other graphic elements. In principle, it should be possible to delete a rather large number of non-significant elements in, e.g., a photograph. As long as some of the significant picture elements are retained, we can still get some idea of the image content. So image design can be changed a great deal without any major change in the perception of image content.

Since the brain fills in missing information and, in certain instances, attempts to make the best possible interpretation of a given stimulus, certain significant graphic elements can also be deleted from images. Missing lines in cartoons can sometimes be as important as the lines actually used. Employing about the right amount of graphic elements and finding the right visual balance are characteristics of skilled and experienced artists, photographers, and graphic designers. Inadequate information results in an inadequate picture. Excessive information results

in visual overload, making a picture hard to interpret. There is an optimum trade-off for each content and application.

Visual literacy

Sutton (1992) compared information literacy, media literacy, and visual literacy. In the USA, a National Forum on Information Literacy was established in 1989. The background was that information is expanding at a very rapid rate. The American Library Association defined information literacy as follows: "To be information-literate, a person must be able to recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information."

Although the term "visual literacy" may be modern, it is not a new idea. Discussions about the use of images have a long history. Ancient philosophers used images for visual communication. In anatomy and medicine, Aristotle employed anatomical illustrations. In mathematics, Phythagoras, Socrates, and Plato used visual images to teach geometry. Jesus Christ and other religious educators and prophets helped their listeners create inner images by the use of different metaphors. In Mesoamerica, the old cultures and civilizations used advanced pictorial messages, especially in their temple cities.

Leahy (1991) pointed out that Aristotle had formed the conceptual idea that certain elements of visual grammar are necessary to visual composition and appeal. Aristotle provided a seminal notion that art and visual literacy theorists Arnheim (1969, 1986) and Dondis (1973) further refined. And Moore and Dwyer (1994) noted that visuals may be the main source for information and communication in many cases today.

There are many aspects of visual literacy and there are many aspects of the use of images for various purposes. Velders (1999) concluded that (p. 10):

> The history of visual communication goes back to the cave paintings 30,000 years ago, the description of it only 2,500. ... visual literacy is 2,500 years old (as a skill) and 30 years young (as a term).

The International Visual Literacy Association, IVLA, was established as a non-profit association incorporated in the State of New York in 1968 to provide a multi-disciplinary forum for the exploration, presentation, and discussion of all aspects of visual communication and their various applications through visual images, visual literacy, and literacy in general. IVLA serves as the organizational base and communications bond for professionals from various disciplines that are interested in visual literacy.

Other concerns are to encourage the funding of creative visual literacy projects, programs, and research, and to promote and evaluate projects intended to increase the use of visuals in education and communications in general.

Definitions of visual literacy

After the first conference on visual literacy was held at Rochester in the USA, Debes (1969) agreed to write the first definition of visual literacy (p. 26):

> Visual literacy refers to a group of vision competencies a human being can develop by seeing and at the same time having and integrating other sensory experiences. The de-

velopment of these competencies is fundamental to normal human learning. When developed, they enable a visually literate person to discriminate and interpret the visible actions, objects, and symbols natural or man-made, that he encounters in his environment. Through the creative use of these competencies, he is able to communicate with others. Through the appreciative use of these competencies, he is able to comprehend and enjoy the masterworks of visual communication.

Since 1969 several researchers interested in visual literacy have developed their own definitions, opinions, and viewpoints. Many have discussed visual literacy with reference to their own, personal background. Thus, individual researchers have placed emphasis on many different aspects of visual literacy.

IVLA provides us with the following four "official definitions" of visual literacy (printed on leaflet, 1989):

1. A group of vision competencies a human being can develop by seeing and at the same time having and integrating other sensory experiences.
2. The learned ability to interpret the communication of visual symbols (images), and to create messages using visual symbols.
3. The ability to translate visual images into verbal language and vice versa.
4. The ability to search for and evaluate visual information in visual media.

The *International Visual Literacy Association* has published a large number of annual books of readings. These proceedings

include papers that have only one thing in common: they all have something to do with seeing. The bulk of all visual literacy research has been done with learning and instruction in mind. Moore and Dwyer (1994) have compiled a text covering twenty-two aspects of visual literacy. Their particular definitional bias is learning, and the ways that visuals affect the learning processes.

Visual literacy definitions

Year	*Author/s*
1968	Debes
1969	Arnheim; Debes
1970	Debes
1971	Chaplin; Paivio
1972	Fransecky & Debes
1973	Dondis
1974	Maccoby & Jacklin
1975	Jonassen & Fork; Spitzer & McNerny
1976	Cochran; Fork & Jonassen
1977	Lucas
1978	Ausburn & Ausburn; Levie; Flory; Williams; Zimmer & Zimmer
1979	Foster
1980	Griffin & Butt; Hortin
1981	Cook; Szabo, Dwyer & DeMelo

1982	Braden & Hortin; Esdale & Robinson; Heinich, Molenda & Russell; Hortin
1983	Earl; Lampe
1984	Griffin & Whiteside; Hortin
1985	Reynolds Myers; Whiteside
1986	Arnheim; Considine; Sinatra
1987	Braden; Curtiss; Lacy; Levie; Schiller
1988	Hanson; Hanson, Silver & Strong; Ragan
1989	Hansen; Kissick & Grob; Pettersson
1990	Clark-Baca; Clark-Baca & Braden; Schallert–Lawrie
1991	Braden & Clark-Baca; Hugo & Skibbe; Leahy; Messaris; Miller
1992	Sutton
1993	Messaris
1994	Bopry; Hortin; Messaris; Moore & Dwyer; Seels
1995	Box & Cochenaur; Brouwer; Messaris
1996	Avgerinou & Ericson; Braden; deLange; Schiffman
1997	Stewig; Avgerinou & Ericson
1998	Allmendinger
1999	Avgerinou & Ericson; Paquin
2000	Avgerinou; Lowe
2001	Avgerinou; Brill, Kim & Branch
2002	Pettersson (2002a)
2003	Avgerinou; Chauvin
2004	Pettersson

2005	Bleed; Rezabek
2006	Burns
2007	Avgerinou; Brill & Kim; Brill, Kim & Branch; Norris; Pettersson
2008	Felten
2009	Avgerinou; Falihi & Wason-Ellam; Pettersson; Santas & Eaker; Sosa
2010	Elkins; Pettersson; Yeh & Lohr
2011	Avgerinou & Pettersson; Brumberger
2013	Hattwig et al.

There has been, and there still are considerable disagreements among researchers and practitioners concerning a precise definition of visual literacy. Sosa (2009, p. 55) noted: "the term 'visual' is evolving and intuitive and has different meanings for different people so, too, 'visual literacy' also may have a variety of meanings."

A large Delphi study showed that the visual literacy scholarly community has not been able to agree on a definition of visual literacy (Brill & Kim, 2007; Brill, Kim, & Branch, 2007). Avgerinou (2003) found that *what the various definitions share in common is greater than what separates them*. Her close examination of visual literacy definitions showed that visual literacy is referred to either a *skill*, a *competency* or an *ability*.

It is clear that it is difficult to describe verbally a concept that is primarily nonverbal. References to selected examples of definitions are shown below. Many definitions or explanations

of visual literacy, and understanding of pictures have been considered important at the time.

Over time, definitions have varied from very narrow to very broad explanations of greater or lesser complexity. In accordance with Avgerinou and Ericson (1999, p. 22) there seem to be as many definitions as there are visual literacists. There has been, and there still are considerable disagreements concerning a common definition of visual literacy. Avgerinou and Ericson (1997) concluded that many have tried to define the concept of visual literacy, but so far they had found no consensus. They remarked (p. 282-283): "it should be apparent that defining Visual Literacy is far from an easy task."

It is clear that it is difficult to describe verbally a concept that is primarily nonverbal. Elkins (2003), Machin (2007) and other researchers have practically rejected the concept of "visual literacy" and search for something else, like communication design, information design, or message design.

Theoretical framework for definitions

Several researchers have defined visual literacy from various theoretical standpoints. Dondis (1973) presented an early definition in her book *A Primer of Visual Literacy* (p. 182): "Visual literacy implies understanding, the means for seeing and sharing meaning with some level of predictable universality. To accomplish this requires reaching beyond the innate visual powers of the human organism, reaching beyond the intuitive capabilities programmed into us for making visual decisions on a more or less common basis, and reaching beyond personal preference and individual taste."

The "universality" Dondis calls for is actually insight, which is one of the highest goals of education. Visual literacy, sometimes called *visuacy*, is a broad, "eclectic in origin" concept (Jonassen & Fork, 1975, p. 7). This statement reflects the many foundational roots of the concept. In addition, it also hints at the complex and complicated task any visual literacist is confronted with when attempting to make sense of the theory for visual literacy.

Contrary to popular and widespread misconceptions, being visually literate does not at all require a person to be skilled in any area of artistic visual work. Flory (1978) advanced the following theory of visual literacy: (a) A visual language exists; (b) People can and do think visually; (c) People can and do learn visually; and, (d) People can and should express themselves visually. Ausburn and Ausburn (1978) focused their attention on developing skills and understandings. They provided this short definition (p. 293): "Visual literacy can be defined as a group of skills which enables an individual to understand and use visuals for intentionally communicating with others."

Obviously, visual literacy requires an interest in developing one's communication skills using visual media, including body language. Braden and Hortin (1982) suggested a definition that avoids the use of much potentially controversial terminology and introduces the concept of thinking in images into the definition. They wrote (p. 169): "Visual literacy is the ability to understand and use images, including the ability to think, learn, and express oneself in terms of images."

The Braden and Hortin approach is similar to that of McKim (1980a, 1980b). McKim suggested that visual thinking is carried on through the employment of three types of visual

images–those we see, those we imagine, and those we draw. The "McKim diagram," consisting of three partly overlapping circles, explains the fluid dynamic that occurs without our conscious awareness or thought. The circles symbolize the idea that visual thinking is experienced to the fullest when seeing, imagining, and drawing merge into active interplay. The visual thinker utilizes seeing, imagining, and drawing in a fluid and dynamic way, moving from one kind of imagery to another.

Hortin (1982) noted that while the concept "visual literacy" had been popular since 1969, no substantial theory of visual literacy had yet been developed. So far most of the visual literacy researchers had discussed various practical aspects of visual literacy and teaching of visual literacy. This is in fact still the case. Heinich, Molenda, and Rusell (1982) recognized that there are different aspects of visual literacy. They compared visual literacy with print literacy and offered the following definition (p. 62): "Visual literacy is the learned ability to interpret visual messages accurately and to create such messages. Thus interpretation and creation in visual literacy can be said to parallel reading and writing in print literacy."

In my opinion this is a very good definition of visual literacy. The definition reflects the perspective that visual literacy is a concept in which particular skills, knowledge, and attitudes can be taught and learned which enhance our abilities to communicate in a variety of visual forms. Several years ago I read and obviously assimilated this definition, and later used the same definition in one of my own books (Pettersson, 1989) without a proper reference to these authors. There are, however, several other definitions of visual literacy.

Hortin (1984) defined visual literacy in the following way (p. 99): "Visual literacy is the ability to understand (read) and use (write) images and to think and learn in terms of images, i.e. to think visually." Reynolds Myers (1985) postulated the following four "Principles of visual literacy theory" (p. 48):

- Visual languaging abilities develop prior to, and serve as the foundation for, verbal language development.
- Development of visual languaging abilities is dependent upon learner interaction with objects, images, and body language.
- The level of visual language development is dependent upon the richness and diversity of the objects, images, and body language with which the learner interacts and upon the degree of interaction.
- The level of visual language development is facilitated by direct learner involvement in the process and equipment used to create objects, visual images, and body language.

On a theoretical basis Sinatra (1986) connected visual literacy to thinking, reading, and writing. He pointed out that visual literacy becomes the basic literacy in the thought processes of comprehending and composing that underlie reading and writing. The non-verbal components of visual literacy are the real "basics" in literacy learning. Sinatra suggested the following definition of visual literacy (p. 5): "Visual literacy is the active reconstruction of past visual experience with incoming visual messages to obtain meaning." The active reconstructive nature of our thought processes means that as visual information is presented to our brains, it is modified and interpreted in the light of what information already exists there.

Piaget (1963) maintained that the sources of thought are not to be found in any verbal language but in the non-verbal, visual-motor reconstruction performed by the very young child during its first two years of life.

Considine (1986) argued that visual literacy attempts to account for both an input and an output set of processes. Visual literacy is said to refer "to the ability to comprehend and create images in a variety of media in order to communicate more effectively." (p. 86) Visually literate students should be able to produce and interpret visual messages. Considine pointed out that since visual literacy is a process requiring the ability to both send, receive, and process visual messages effectively in order to participate in two-way communications, visually literate individuals have to develop a variety of proficiencies.

Clark-Baca (1990), Clark-Baca and Braden (1990) and Braden and Clark-Baca (1991) dealt with the complexity of various definitions. Clark-Baca's Delphi Study (1990) involved input from 52 experts in the field of visual literacy. The final round yielded 167 statements that were identified as constructs that define, describe, or elaborate upon visual literacy. These statements can be seen as an "index to the field." Braden and Clark-Baca (1991) proposed "a conceptual map which would serve as a graphic organizer of visual literacy constructs" (p. 156).

Avgerinou (2000) used the following operational definition of visual literacy (p. 26): In the context of human, intentional visual communication, *visual literacy* refers to a group of largely acquired abilities, i.e. the abilities to understand (read), and use (write) images, as well as to think and learn in terms of images."

According to Braden (1996, p. 9) there are two major impediments to research on visual literacy. “The first is a lack of a widely accepted definition of the term *Visual Literacy* itself. The second, perhaps a consequence of the first, is a lack of a cohesive theory.”

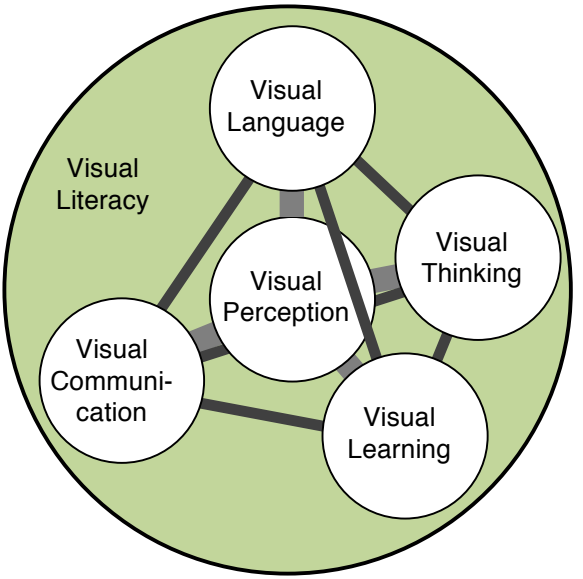
Avgerinou (2001) identified the following points of convergence among the multitude of the definitions referred to the concept visual literacy:

- A visual language exists;
- Visual language parallels verbal language;
- Visual literacy is a cognitive ability but also draws on the affective domain;
- The terms “ability,” “skill,” and “competency” have been invariably and interchangeably used to describe visual literacy;
- The visual literacy skills have been specified as (a) to read/decode/interpret visual statements, (b) to write/encode/create visual statements, and (c) to think visually;
- The visual literacy skills are (a) learnable, (b) teachable, (c) capable of development and improvement;
- The visual literacy skills are not isolated from other sensory skills;
- Visual communication, visual thinking, and visual learning are inextricably linked to visual literacy;
- Visual literacy has accepted and incorporated theoretical contributions from other disciplines;
- Visual literacy’s main focus is intentional communication in an instructional context.

Many current definitions of the term visual literacy has an emphasis on *creating visual materials*, not just interpreting visual messages (Brumberger 2011; Hattwig et al. 2013; Felten 2008).

According to Mayall and Robinson (2009, p. 49) in-service teachers' failure to incorporate visual literacy tools in instruction stem from a lack of knowledge of the "theoretical principles and guidelines."

Having considered a vast literature on visual literacy, Avgerinou and Pettersson (2011) proposed that a *theory of visual literacy* should be grounded on the following conceptual components: (a) Visual perception, (b) visual language, (c) visual learning, (d) visual thinking, and (e) visual communication.



This is an illustration of the visual literacy theory and its components.

Visual literacy skills

Some researchers, as well as some practitioners, have provided definitions of visual literacy with emphasis of the holistic success of the actual use of visual literacy techniques in producing visual messages, in art, in everyday life, as well as in teaching. When Cochran (1976) asked delegates at a media leadership conference to define the term "visual literacy," the 62 definitions indicated that 52 different phrases were used to define the adjective "visual" and that three major meanings evolved for the word "literacy," as a group of competencies, as a process or method of teaching, or as a movement. All the delegates agreed that visual literacy was used to refer to three major diverse categories: human abilities, teaching strategies, and the promotion of ideas.

Debes (1969) identified 35 different visual literacy skills. These skills range from the ability to distinguish light from dark to the ability to read and express a sequence of body language arranged to express a personal emotion. In the work of Fransecky and Debes (1972) the objectives for the visually literate student are (p. 12):

- To be able to read visuals made for intentional communication.
- To be able to plan visuals for intentional communication.
- To be able to create visuals for intentional communication.
- To be able to combine visuals and verbals for intentional communication.

Esdale and Robinson (1982) argued that visual literacy should be integrated across all curricular areas in an effort to both expand ability and to prevent categorization which could limit

learning and use of visual literacy skills. Lacy (1987) concludes that visual literacy is a communication skill like verbal literacy. She defined visual literacy in the following way (p. 46):

> It (visual literacy) can be defined as the ability to identify, analyze, interpret, evaluate, and produce visual messages. A visually literate person has acquired skills in gathering information from such straightforward visual messages as another person's body language. Or from complicated visual images that are combinations of new technologies like video, computer, and enhanced photography. And visually literate persons can both mentally image and communicate to others by producing a visual message themselves.

Schiller noted that all the different viewpoints of visual literacy show that every visual medium has its own characteristic form. Thus, there are clearly different visual literacies, and there are different skills to be learned in terms of their characteristic techniques and methods of expression. As a consequence people should concentrate on more limited concepts, such as computer literacy, film literacy, video literacy, and television literacy. Indeed, it might be impossible to create one single definition of the broad concept of visual literacy.

Hanson (1988) argued that the skills and understandings of visual literacy are not taught in schools in any organized way. However these skills are directly related to academic success, and especially to success in reading. Hanson proposed the following seven levels of visual literacy. The student can (p. 422-423):

1. Recognize instances of the same element in different contexts
2. Produce graphic likeness
3. Recognize an object when seen from different angles (Gardner, 1983, p. 170)
4. Transform one element into another by imagining movement, rotation, inversion, or internal displacements among the parts (Thurstone, 1937, p. 32-39)
5. Identify or correctly configure elements within a spatial configuration which could otherwise represent distortions because of the observer's orientation (Karp, 1962)
6. Identify lines of force, tension, balance and composition, i.e., to identify the principles that make the visual arts aesthetically satisfying (Aero & Weiner, 1983, p. 65-74), and
7. Identify resemblances, symbols or signs across seemingly unrelated areas of existing knowledge or personal experience (Gardner, 1983)

Hanson, Silver and Strong (1988) provided similar thoughts. Whiteside (1985) discussed visual literacy awareness in college-level educational media courses. He used a seven-step approach to plan and implement visual literacy modules. These steps may be summarized as follows: 1) Defining visual literacy. 2) Identifying visual literacy needs. 3) Selecting and prioritizing needs, goals, and objectives. 4) Selecting appropriate media. 5) Planning classroom activities. 6) Implementation of visual literacy modules. 7) Planning for future activities.

Whiteside concluded his paper with this remark (p. 100): “We should provide visually enhanced learning to optimize our students’ entrance into the world of tomorrow.”

Hugo and Skibbe (1991) concluded that medical and health educators in South Africa are facing many problems related to lack of visual literacy skills. Communication and education often fail because some groups are unable to interpret visual messages correctly. In South Africa pictures can often be a hindrance rather than an advantage in teaching. The misconception that any visual material has educational value still exists. Hugo and Skibbe found that visual literacy might be a key factor in effective medical and health education.

Considine and Haley (1992) noted that the effective integration of imagery into instruction could facilitate the student's ability to read, recall, and comprehend the content of the message. Visual literacy can therefore support traditional literacy. In cultures where magazines, newspapers, film, television, and video proliferate the natural learning of visual literacy becomes incidental and develops over a long period. In fact this learning may never occur. Brouwer (1995) concluded that pictures are not always effective as a means of communication with illiterates in rural Africa. Visual language and visual conventions need to be taught just as much as a verbal language.

In cultures where magazines, newspapers, film, television, and video proliferate the natural learning of visual literacy becomes incidental and develops over a long period. In fact this learning may never occur. In South Africa deLange (1996) proposed that adults in developing countries, that are not exposed to a visual culture as found in North America and Western Europe, might never develop a basic ability to read pictures. Their frame of reference and their level of understanding could possibly extend only to the limited number of visuals that they have actually been in contact with. Thus, it may not be enough to

merely modify visuals in print media for these cultures. In many situations new pictures may be needed.

Schiffman (1996) studied information design guidelines for designing and evaluating visual components of educational materials for ethnic populations within the USA. She concluded that it is necessary to adopt visual messages to various ethnical groups (p. 76): "Visually translating health educational materials will be critical to the success of communication efforts, particularly as our population continues to change ethnically and less developed countries continue to develop."

In a society that is becoming increasingly visually oriented (Wilcox, Ault and Agee, 1992) and diverse, few people appreciate the critical role of visual literacy and visual communication. Stewig (1997) studied what fifth grade children wrote about picture books. He concluded that despite widespread interest in visual literacy among psychologists and art educators, little, if anything is done in most elementary schools to develop children's skills in visual literacy. As communicators we need to understand the types of issues that become relevant when designing information materials across cultures. Visuals must always be relevant to the intended audience.

The visual literacy skills are not isolated from other sensory skills. It is generally believed that there is exchangeability of information received and transmitted by all sensory channels. Given this, visual literacy is thought to improve the development of verbal (written and oral) literacy (Avgerinou, 2003). The visual literacy skills are (a) learnable, (b) teachable, and (c) capable of development and improvement. Although research has not always substantiated these allegations, most visual literacy definitions are centred on them.

Felten (2008, p. 60) concluded: "living in an image rich world, however, does not mean students (or faculty and administrators) naturally possess sophisticated visual literacy skills." According to McKenzie (2008, p. 1) the ability to create and interpret information from a multiplicity of visual sources is becoming a 'survival skill' in today's schools. Hattwig et al. (2012, p. 61) argued for higher education's support of visual literacy since it represents essential competencies for 21st century learners.

Vermeersch & Vandenbroucke (2015) used the "culture in the Mirror theory" in order to study aspects of visual culture in the classroom. They discussed a skill-based classification of visual literacy skills: 1) perception, 2) imagination and creation, 3) conceptualization, and 4) analysis. They found that curriculum standards refer only peripherally to the use of visuals in compulsory education in Belgium.

Visual literacy competencies

According to Fransecky and Debes, the competencies of visual literacy are defined as reading, planning and creating visuals, and combining visuals and verbal information for intentional communication.

Paquin (1999) discussed "competencies of visual literacy." He combined visual literacy skill perspectives of Fransecky and Debes (1972), Hansen (1989), and Seels (1994), with the visual literacy outcome perspective, proposed by Ragan (1988). Paquin made an "expanded taxonomy of visual literacy outcomes" (p. 247). The "expansion" is the addition of outcomes that require combining of visuals and verbal information for

successful visual communication. In the list below these expansions are marked with an *.

Expanded taxonomy of visual literacy outcomes

A. Primary level

1. *Manipulation*:
   Holding, touching and changing objects in the environment.
2. *Construction*:
   Creating simple works, paintings, cut outs. Taking pictures.
3. *Abstractions*:
   * Identification of concepts–sizes, shapes, colours, names with objects, etc.

B. Skilled level

4. *Manipulation*:
   Using tools for problem solving; sewing, taking apart and reassembling things.
   * Sequencing/describing photographs.
5. *Construction*:
   Drawing with perspective.
   Controlling variables when taking/processing pictures.
   Origami or other complex constructions.
   * Interpreting/following mixed instructions.

6. *Abstractions*:
   Creating visual plans/patterns in two dimensions.
   Specifying photographic treatment for objects, actions and sequences.
   * Creating visuals from verbals and vice–versa.

C. Advanced level

7. *Manipulation*:
   Mental manipulations of complex representations; maps, multivariate statistical models.
8. *Construction*:
   Ability to draw imagined objects in 3-D, producing original conceptualizations.
   Processing one's own original photographic style.
   * Develop meaningful charts and graphs from given data sets.
   * Creating flyers, advertisements or other mixed communication.
9. *Abstractions*:
   Multiple holistic appositional forms of abstract thought; lateral thinking, visual intuition, unique visual invention.
   * Describe conceptual visual ideas verbally.

Visual literacy abilities

Messaris (1994) proposed that visual literacy is largely a natural process. He argued that visual literacy is unlikely to lead to any cognitive advantages analogous to those that result from learning a language. Messaris (p. 165) does not see images as a language. Images are distinguished from language and from other modes of communication by the fact that they reproduce many of the informational cues that people make use of in their perception of physical and social reality. According to Messaris our ability to infer what is represented in an image is based largely on this reproductive property, rather than on familiarity with any arbitrary conventions. Arbitrary conventions play a major role in the interpretation of language, mathematics, and so on.

Schiller (1987) developed a diagram attempting to show the input and output model of human perception and expression suggesting how the different literacies have developed from the abstractive processes of symbolic and image expression. He noted that every image is an aesthetic abstraction with a depictive capacity. This capacity ranges from highly abstract, such as printed letters of the alphabet, to exacting isomorphism, such as realistic paintings. Schiller claimed that in all the imaginative visual arts, the composition is the fundamental unit–and that composing is the fundamental process. He stated that: "It is in providing a deeper understanding of this process that visual literacy can offer education a pathway into the future that can begin to focus on the knowledge most worth knowing" (p. 282).

In an attempt to give teachers and administrators the sense of a new direction, Schiller offered the following definition of visual literacy (p. 276): "Visual literacy is an ability to interpret by means of trained perceptual capacities feelings, ideas, and information and to communicate them imaginatively with compositions created via a diversity of visualizing mediums."

According to Brumberger (2011, p. 21) the best definitions of visual literacy contain "both an interpretative and a productive component." According to Matusitz (2005) American students may be characterized as (p. 101, p. 101): "passive consumers in the classroom." Students are not employing critical analysis of visual communication. And Felten (2008) noted that it's not enough to simply receive a message in a passive manner. A truly visually literate person must be able to construct meaning out of the images that are shown.

The visual literacy ability has been specified as (a) to read/decode/interpret visual statements, and (b) to write/encode/

create visual statements. A third visual literacy ability is to think visually, although it could be argued that it has been implied in most definitions, has been added to and explicitly stated in more recent definitions (Avgerinou, 2003). It's not enough to simply receive a message in a passive manner. A truly visually literate person must be able to construct meaning out of the images that are shown (Felten, 2008).

Farrell (2013) investigated the measurement of VL ability across the US in order to establish a baseline VL ability measure from which to make vital decisions in the purposeful training of visual literacy within teacher preparatory programs and professional development within school districts. Her findings emphasized the need for more development in critical engagement with visuals especially as it applies to Common Core State Standards assessments, consumer-driven marketing and power roles, and new modes of digital authorship in a media-saturated society.

According to Coleman et al. (2010) an "effective use of graphics" is multifaceted. It includes being able to organize information, to create graphics, to read graphics, to locate specific information within a graphic, and to communicate with others through the use of graphics. The effective use of graphics must be taught (Gerber et al., 1995; Kress and van Leeuwen, 2006).

Visual literacy can help students become more aware of the social structures and representations in society, make them more aware of the reinforcing media messages they encounter on a daily basis (Mihailidis & Hiebert, 2005) and recognize their own biases when producing creative works.

Summary perspectives on visual literacy

Bopry (1994) summarizes that the visually literate are those capable of applying "grammar and syntax of visual language" and translating "visual language to verbal language and vice versa." Braden (1987) identified three "domains" of visual literacy:

1. Visualization, described as "aspects of vision in the human process of thinking and communication" (p. 7). In this domain Braden included elements such as visual syntax, visual design, visual expression, and visual thinking.
2. The "theory–research–practice trilogy as it applies to visual literacy" (p. 6). This includes elements such as instruction, design, communication, and persuasion.
3. Technology, including the effects of technological developments upon the other two domains of visual literacy. Braden included in this category electronics and television, computers, and reprographics.

Griffin and Whiteside (1984) argued that visual literacy theory should stimulate practical applications, and they suggested that visual literacy should be approached from three different perspectives:

1. The theoretical perspective, which incorporates the philosophical, psychological, and physiological aspects of learning.
2. The visual language perspective, which incorporates a receiver-oriented approach committed to helping people become visually literate by effectively relating to visual stimuli.

3. The presentational perspective, which incorporates a presenter-oriented approach, and the improvement of the communications process through design of visual stimuli.

Visual literacy is really a broad and interdisciplinary concept including biological perspectives, communication perspectives, presentational perspectives, religious perspectives, social perspectives, technological perspectives, visual language perspectives, and bits and pieces from several other "established fields" of research. Many researchers from different disciplines have explained their views and interpretations and written about visual literacy from their various perspectives. Selected references to such papers are shown in the table below.

Visual literacy is related to many different areas.

Discipline	*Author/s*
Advertising	Griffin & Whiteside 1984; Besser 1987; Velders 1996; Ketelaar, Gisbergen & Beentjes 2012
Aesthetics	Bakony 1983; Metallinos 1991; Seward Barry 1994; Velders 1996; Fellman Fattal, 2012.
Adult education	Kissick & Grob 1989; Velders 1995
Anatomy	Metallinos 1994
Anthropology	Hill 2003
Archeology	Fee 1999; Fee & Fee 2012
Art	Arnheim 1969; Gonsalves 1983; Arnheim 1986; Curtiss 1987; Hortin 1994; Seward Barry 1994; Velders 1996; Coman 2004; Spalter & van Dam, 2008; Yenawine 2008
Art education	Dondis 1973; Mackenzie 2012

Art history	Garoian 1989; Velders 1995, 1999; Hill 2003
Audiovisual media	Cochran 1976
Biochemistry	Schönborn & Anderson 2006; Towns et al. 2012
Biology	Lord 1985; Wandersee 1992; Flannery 2006
Brain research	Lampe 1983; Sinatra 1986
Business communication	Brumberger 2005; Hentz 2006
Business presentations	Griffin & Butt 1980; Griffin & Whiteside 1984; Griffin 1994
Cable television	Johnson 1988
Chemistry	Talley 1973
Child development	Ausburn & Ausburn 1978
Clothing	Giesen & Robinson 2007
Cognitive development	Reynolds Myers 1985
Cognitive style	Lampe 1983; Hanson, Silver & Strong 1988;
Communication	Curtiss 1987; Hirsch 1987; Wisely, Kennett & Bradford 1989; Schallert–Lawrie 1990; Wisely 1994; Roth & Roth 1998; Felten 2008
Computer graphics	Spalter & van Dam, 2008; Bodzin & Cirucci, 2009; Chang, Quintana, & Krajick, 2009
Computer science	Whiteside 1983; Griffin & Whiteside 1984; Ragan 1988
Computer literacy	Considine & Haley 1992
Creativity	Couch, Caropreso & Miller 1994
Cultural studies	Hill 2003
Curriculum	Martinello 1985; Miller 1987; Ragan 1988; Robinson 1991

Design	Spalter & van Dam, 2008
Education	Dondis 1973; Levie 1978; Muffoletto 1983; Muffoletto 1984; Evans, Watson & Willows 1987; Miller 1987; Bertoline, Burton & Wiley 1992; Moline 1995; Frey & Fisher 1998; Williams 2001; Hill 2003; Bleed 2005; Schwartz 2008; Pedersen & Finson, 2009; Finson & Pederson 2011; Palmer 2011; Fee & Fee 2012
Engineering	Earl 1983; Miller & Bertoline 1991; Miller 1992
English	Foster 1979; Barry & Leaver 1989; Connors 2012
Ethics	Limburg 1988
Film studies	Foster 1979; Bakony 1983; Miller 1989; Hill 2003; Malich & Kehus 2012
Games	Bleed, 2005
Graphic design	Hardin 1983; Bennett 1989; Pettersson 1989; Braden 1994
History	Schiller 1987; Leahy 1991; Coventry et al. 2006; Fee & Fee 2012
Iconology	Velders 1995
Illustration	Levie & Lentz 1982; Thompson 1994
Image design	Pettersson 1989; Thompson 1994
Infology	Pettersson 1989
Information literacy	Sutton 1992; Harris 2010
Information techn.	Braden 1987
Instruction	Levie 1978; Bennett 1989; Fredette 1994
Instructional design	Levie 1978; Heinich, Molenda & Russel 1982; Braden 1989; Sugar et al., 2012
Journalism	Barnhurst & Whitney 1991
Language	Greenlaw 1976; Griffin & Whiteside 1984; Wilson 1988

Learning	Dwyer 1978; Colwell, Mangano & Hortin 1983; Lampe 1983; Hanson, Silver & Strong 1988; Curtiss 1990; Stern & Robinson 1994;Seward Barry 1997; Glasgow, 1994
Library science	Good 1987
Literacy	Wilson 1988
Literature	Fee & Fee 2012
Mathematics	Maccoby & Jacklin (1974)
Media	Cochran 1976; Whiteside 1985, Lloyd-Kolkin & Tyner 1990
Media education	Velders 1995
Media literacy	Sutton 1992
Meteorology	Lowe 2000
Neurophysiology	Metallinos 1994
Object language	Moore 1994
Perception	Haber & Myers 1982; Hanson, Silver & Strong 1988; Sutton 1990; Metallinos 1991; Messaris 1993; Stern & Robinson 1994; Seward Barry 1994; Seward Barry 1997
Philosophy	Debes 1970; Leahy 1991; Hortin 1994
Photography	Muffoletto 1982; Oudejans 1988; Sutton 1992
Phototherapy	Krauss 1984; Weiser 1984
Physiology	Metallinos 1994
Political science	Hill 2003
Psychology	Hanson, Silver & Strong 1988; Moore 1988; Hortin 1994; Hill 2003
Reading	Levin & Lesgold 1978; Sinatra 1986; Bennett 1989

Science	Lowe 2000; Marquez, Izquierdo, & Espinet, 2006; Northcut 2007; Malamitsa, Kokkotas & Kasoutas 2008; Coleman, McTigue, & Smolkin, 2011; Finson & Pederson 2011; Rybarczyk 2011
Semiology/ semiotics	Muffoletto 1994; Velders 1995; Hill 2003; Finson & Pederson 2011
Teacher Education	Muffoletto 1983
Teaching	Barry & Leaver 1989; Garoian 1989; Rezabek 1990; Robinson 1992; Lowe 2000
Technology	Lowe 2000; Chauvin, 2003; Bell, Gess-Newsome, & Luft, 2008; Brumberger 2011
Television	Foster 1979; Becker 1987; Johnson 1988; Robinson 1988; Barry & Leaver 1989, Miller 1989; Adler 2006
Test design	Avgerinou & Ericson 1997; Avgerinou 2000
Text design	Bennett 1989
Textiles	Giesen & Robinson 2007
Thinking	McKim 1980a 1980b; Braden & Hortin 1982
Video	Williams 1988; Hobbs 1989
Visual art	Arnheim 1969, 1986; Gonsalves 1983; Curtiss 1987; Hortin 1994; Seward Barry 1994; Velders 1996
Visual cognition	Sinatra 1986; Miller & Burton 1994; Seward Barry 1997
Visual design	Thompson 1994
Visual communica-tion	Dondis 1973; Seels 1994; Sewell 1994; Brumberger 2011
Visual culture	Spalter & van Dam, 2008; Bernard, 1990b.
Visual language	Moore & Dwyer 1994; Braden 1994; Seward Barry 1994; Kovalik, 2005; Singer, 2010
Visual learning	Dwyer 1978; Moore & Dwyer 1994; Nelson Knupfer 1994; Seels 1994

Visual intelligence	Seward Barry 1997
Visual thinking	Arnheim 1969; Seels 1994
Visualization	Spalter & van Dam, 2008
Writing	Wilson 1988

It may be concluded that visual literacy is a very broad and interdisciplinary concept including theoretical perspectives, visual language perspectives, presentational perspectives, technological development, and bits and pieces from several other "established fields" of research. There are of course more examples to be found. A large number of papers have been presented at the Annual Conferences of the International Visual Literacy Association and many have been published in the *Selected Readings* and in the *Journal of Visual Literacy*.

Despite all our combined efforts during the past 33 years visual literacy has not been able to attract enough interest from society and enough interest from those responsible for the school curricula around the world. An important reason for this may be a general lack of focus. In my view we need to consider combined verbal-visual messages, not only words and not only visuals when we study communication and communication related issues. This is where message design, and its different subareas, may play an important role for visual literacists.

The various literacies and modes of thinking required in an information society will challenge the capacities of every person. While a variety of means are being found to help build and maintain these information resources, new vistas of capacity lie before us. These opportunities, and how we respond to them

will determine our collective future in a world grown closer through mutual dependence upon shared intellectual resources.

Providing clarity

The *legibility of a graphical message* is determined by the technical design of texts and pictures, that is, their *clarity*. The information designer will have to make the content stand out clearly from the background. (See book 4 *Graphic Design* for a discussion about legibility of text.)

Legibility of pictures

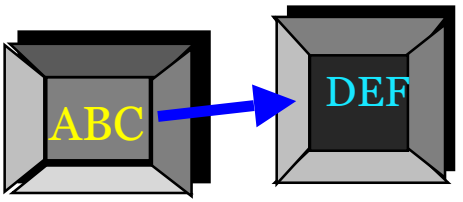
A message has good legibility if it is easy to read, and if the reader can easily see and distinguish all different parts of the message. Legibility can be measured rather objectively and its quality is assessable whether we understand the content of the message or not. Dissatisfaction with the execution of a message may also cause dissatisfaction with the content of the message. Therefore the information designer has to consider the legibility of text printed on paper, displayed and projected on screens, as well as legibility of pictures, legibility of layout, legibility of symbols, legibility of numerals, and legibility of colours. The information designer should:

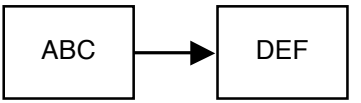
- Use picture elements that are bold and large enough.
- Use a style guide for picture elements in schematic pictures.
- Set words in images and pictures bold and large enough to read.

A “good” visual has a high level of picture quality. It is well worth reading and is executed so as to be legible and readable and be displayed in an optimum context in an appropriate for-

mat. The visual should convey information without ambiguity. It should be stylish and attractive, and is often, but not necessarily, also aesthetically pleasing. A schematic drawing has good legibility if it is easy to read, from the viewpoint that the reader should easily be able to see and distinguish all the different parts of the schematic picture.

A "poor" visual has a low level of picture quality. It displays poor legibility and poor reading value. It conveys information poorly, is seldom aesthetically pleasing, and often ambiguous. A "poor" visual has a low level of picture quality. It displays poor legibility and poor reading value. It conveys information poorly, is seldom aesthetically pleasing, and often ambiguous. Dwyer and Dwyer (1989, p, 122) pointed out "the value of different types of visual illustrations is not a valid assessment of instructional effectiveness that is, aesthetically pleasing visuals may not be of great instructional value."





Here is a simple schematic picture with poor legibility (left). Unfortunately this "style" is quite common in technical illustrations today. When colour is used in this kind of false three-dimensional picture elements, legibility may be even worse than in this example. It is really hard to read the message. The second illustration (right) carries the same content. However, in this illustration it is easy to read the message.

Wileman (1993, p. 86) provided the following checklist with questions for evaluation of visuals with reference to clarity:

1. Are the words and images large enough to see?
2. Are the words and images bold enough to see?
3. Is there good contrast between figure and ground?
4. Is the visual appropriate for the intended audience?
5. What visual devices are used to direct the viewer's attention?
6. Does the visual contain only the essential information?
7. Are appropriate visual sequencing techniques used to present complex ideas?

It is a good idea to use this checklist for text as well as for pictures in order to achieve clarity of the message.

Graphics and schematic pictures can help readers see and comprehend complex patterns (Horton, 1991). All kinds of visuals should contain essential information and have a good contrast between figure and ground.

Legibility of symbols

The use of symbols has a long tradition and various symbols can be used to aid communication. The information designer should:

- Use distinct colours and simple graphical elements to design symbols that will function in any size.
- Design solid figures with a distinct contrast to the background.
- Use characters and graphical elements that are bold, distinct and large enough.

A clear and stable figure to ground articulation is essential in graphic symbols (Dewar, 1999; Easterby, 1970). The figure ("foreground") should be organised as one unit with close boundaries, appropriate line thickness and any other graphical means that help the visual system to organise the figure as one unit. Criteria for individual symbols or sets of symbols depend on their application (Dewar, 1999). It is appropriate to use silhouette (side) views of certain components such as vehicles.

Legibility distance is essential in the case of traffic signs and many building signs, but not for symbols on maps or consumer products. Black text on a yellow background is superior as compared to white on black, white on grey and black on white (Waller, 2007). Complex warning messages need a combination of pictographs and words (Dewar & Arthur, 1999). Warnings must have high contrast relative to the background (Barlow & Wogalter, 1991; Sanders & McGormick, 1993).

Legibility of maps

Maps must have good legibility. Therefore the information designer should:

- Use bold and distinct symbols in a consistent size.
- Restrict the number of typefaces and complexity of patterns.
- Provide distinct contrast in form and dimensions.

A graphic language used on maps consists of visual variables (Baudoiun & Anker, 1984; Bertin, 1967). The most important variables are position and place, form (of symbols), directions, colour, density or greyness, granularity or texture, and size of symbols. A variable can be a dot, a line, or an area. Discriminatory responses to map symbols depend on contrast in *form, di-*

mension, and *colour* (Keates, 1982). The problem of discrimination is generally more critical in monochrome maps, in which only contrasts in form and dimensions are possible for lines and small symbols. Brumberger (2011) suggested that visual literacy is particularly relevant in regard to maps.

The use of colour on maps introduces a large number of variables, which may enhance contrast, and therefore extend the number of perceptual differences that can be employed in discrimination. The effect is to *aid legibility*, and therefore to increase the total range of information which the map can present. Shape and colour components are often used for designating a link or relationship between groups of messages. The recognition of geographical features is much enhanced when areas are differentiated by hue. At the same time, complex colour arrangements may raise problems in discrimination, so that although multi-colour maps enlarge the graphic possibilities, they also increase the probability of errors in the judgment of discrimination. The most common case of quantitative judgment on maps occurs in the use of proportional symbols, that is, point or line symbols constructed to represent specific quantities.

Providing simplicity

Readability is determined by how well the contents and the presentation of the contents are adapted to the readers. Today readability of a message involves the reader's ability to understand the style of text, the style of pictures and the style of graphical form. The choice of words, symbols, and picture elements creates the style. The readability is determined by con-

tent and formulations, and how well the language and style are adapted to the readers.

There is a close relationship between guidelines that are aimed at providing *simplicity* and guidelines that are aimed at *facilitating perception, processing and memory*. Simplicity in a message will result in easier and more efficient perception, processing and memory of that message. The information designer has to consider the readability of text, the readability of pictures, as well as the readability of graphical form. Providing simplicity in text, illustrations, and graphical form is probably one of the most important principles in information design. It should be a priority for the information designer to make use of the guidelines related to these areas.

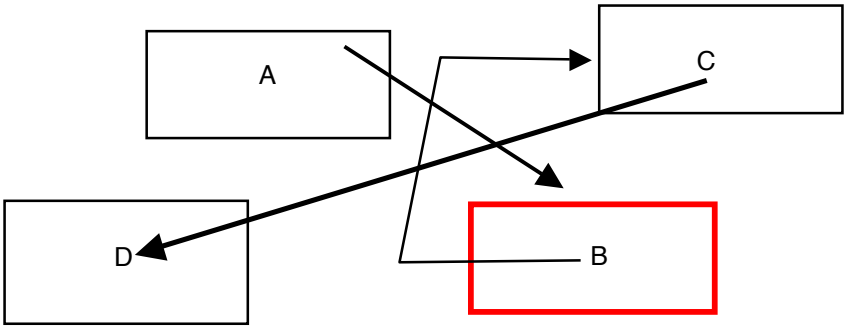
Readability of pictures

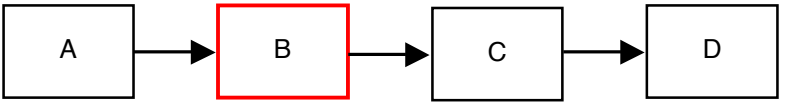
Pictures in information and learning materials must have good readability. Therefore the information designer should:

- Write captions to explain pictures.
- Choose illustrations carefully and use visual sequencing techniques to present complex ideas.
- Leave out needless pictures and picture elements and avoid excessive image detail.

All sighted people are capable of “looking at” a picture. But people can also learn to “read” pictures as they learn to read words. The language of pictures used in all media should be tailored to reader perceptions. For example, the degree of reading difficulty should gradually increase in textbooks intended for different school grades. It is reasonable to assume the following regarding pictures designed to convey information and knowledge:

- A picture that is easy to read and comprehend conveys information more readily than a picture that is hard to read and comprehend.
- A picture that evokes a positive response conveys information more effectively than a picture that evokes a negative response when motivation is identical in both instances.
- Even a “poor” picture will work when viewer motivation is high, but a “good” picture would then work even better.





Here the upper illustration is a simple example of a schematic picture with poor readability. It takes some time to figure out the relationships between the four picture elements A, B, C, and D. The lower illustration is an example of a schematic picture with good readability. The content is the same as in the upper illustration. However, here it is much easier to understand the relationships between the picture elements A, B, C, and D.

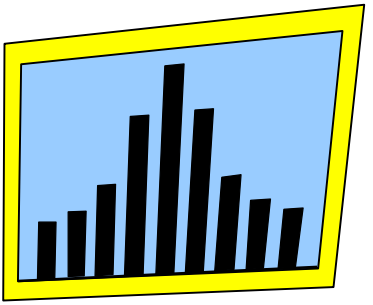
Depiction of contents

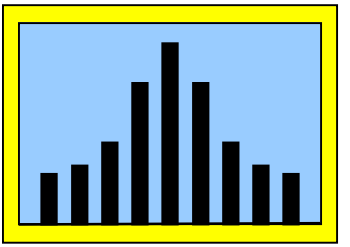
An analysis of a photographic portrayal can identify positive and negative depictions of individuals seen in the photographs (Moriarty & Garramone, 1986; Wanta & Chang, 2000). Individuals are viewed more positively when they are shown walking, running or moving than just sitting or standing (Moriarty & Popovich, 1991). Visuals with varied degrees of realistic detail can be used to reduce differences in the performance of learners with different levels of prior knowledge of the subject matter (Dwyer, 1994).

Style of illustration

The *style of illustration* is decided by the specific choice of drawings, photographs, schematic pictures, and other kinds of pictures, as well as consistency, expressions, picture elements, and symbols. Images can be readable in the sense that they inspire cognitive and affective processing. A drawing style that includes many different kinds of lines, patterns, shadings, and inconsistent use of symbols may obstruct the reading and understanding of the picture content.

Instructional illustrations have good readability when: (a) The subject matter is familiar to the audience, (b) the subject matter is depicted in a realistic manner, (c) they lack excessive image detail that may distract from the main message, and (d) the pictorial conventions are familiar to the audience (Boeren, 1994; Brouwer, 1995; Colle & Glass, 1986; Hugo, 1996; Lent, 1980; Van Aswegen & Steyn, 1987; Zimmermann & Perkin, 1982).





This situation (left) is far too common in Power Point-presentations. The second picture (right) is projected in a correct way.

Captions

It is possible to interpret most pictures in several different ways until they are ”anchored” to one interpretation by a caption (Barthes, 1977; Pettersson, 1987, 1990). The only way to assure that information conveyed by pictures in information materials is clear and unambiguous is to write a caption for each picture and tell the reader what to see (Bernard, 1990a; Zimmermann & Perkin, 1982).

See the sections about captions in the books *Information Design 2–Text Design* and *Information Design 4–Graphic Design* for further information.

Effectiveness

Most people believe that pictures tell the truth (Lefferts, 1982). However, few realize that what they think they see in pictures depends on what they expect to see in them (Berthoz, 2010), and are expected to learn from them (Singer, 2010). The effectiveness of a visual depends on the medium, on the type of information, and also on the amount of time learners are permit-

ted to interact with the material (Dwyer, 1972). Increasing the size of illustrations by projecting pictures does not automatically improve their effectiveness in facilitating the achievement of the learners. Also language and cultural differences may impact the effectiveness of visuals (Kovalik, 2005; Singer, 2010). Furthermore it is also known that stylized and "simple" pictures are more effective than complex pictures (Melin, 1999b).

Cermak and Craik (1979) found that if learners perceive a task as more demanding, they tend to process the material more deeply and are better able to remember the main ideas and details in a text. Weidenmann (1988) found some support for this relationship in his research on the effectiveness of pictures.

Usefulness

Picture readability is positively correlated with both the aesthetic rating and usefulness in teaching. The aesthetic rating and assessed usefulness in school were also strongly correlated (Pettersson, 1983a).

According to design guidelines by Lent (1980), Zimmermann and Perkin (1982), Colle and Glass (1986), Van Aswegen and Steyn (1987), Boeren (1994), Brouwer (1995) and Hugo (1996), an instructional illustration has good readability when:

- the subject matter is familiar to the audience,
- the subject matter is depicted in an realistic manner,
- it lacks excessive image detail that may distract from the main message,
- the pictorial conventions are familiar to the audience.

Picture readability indexes

I have developed a "Picture readability index" (BLIX) (Pettersson, 1983a). A "Photograph readability index" (PRI) was developed a few years later a.

BLIX

Values range from zero to five. A BLIX-5 picture:

- Is executed in a true-to-life colour/has a clear contrast and grey scale in the picture.
- Has a shape other than a square or a rectangle or covers an entire page.
- Has a caption which is brief, easy to understand, and deals with the picture.
- Is unambiguous and not too "artistic."
- Has a dominant centre of interest at or near its optical centre (middle of the picture) and few details, which can be regarded as distracting.

Picture readability is positively correlated with both aesthetic rating and usefulness in teaching. When the research started in 1979, seventeen variables were directly connected to the content and execution of the visual and two to the context. The investigated variables were the external shape, external contour, size, colour versus black and white, colour intensity, contrast, grey scale and darkness-lightness, degree of realism, number of details, number of centres of interest, location of centre of interest, presence of symbols and reading aids, perspective, illusions, subject common or uncommon, size of main subject, technical quality, caption, and relationship between caption and picture.

Experiments with ranking and rating of test-pictures showed that pictures with high BLIX-values were ranked and rated better than those with lower values by children as well as by adults. Experiments with the actual making of pictures showed that despite detailed instructions on the execution of the visuals, there was still plenty of scope for individual creativity. It was also shown that informative pictures drawn so that their BLIX-ratings were high (more than 4.5) were to a large extent rated as a aesthetically pleasing, rated as "suitable" or "very suitable" for teaching, and did not take more time to make than pictures with lower BLIX-ratings. Instructions on the execution had to be followed if reliable and satisfactory results were to be obtained.

Two of the visuals produced in the experiment with actual making of pictures. These visuals got BLIX ratings 4.8 (left) and 2.5 (right). Here the visuals are reduced and not in colour.

BLIX-rating-scheme

Questions		*Yes/No*
1	(a) Colour picture: The picture is executed in a true-to-life colour. (b) Black and white picture: The contrast and gray scale in the picture are clear.	
2	The picture has a shape other than a square or a rectangle or covers an entire page.	
3	The picture has a caption that is brief, easy to understand and deals with the picture.	
4	The picture is unambiguous and not too "artistic".	
5	The picture has a dominant centre of interest at or near its optical centre (middle of the picture) and few details that can be regarded as distracting.	
Total number of yes answers		

The total number of "yes" answers provides a direct value for picture readability in which 0 = "a virtually incomprehensible picture," 1 = "very hard to read," 2 = "hard to read," 3 = "neither hard nor easy to read," 4 = "easy to read," and 5 = "very easy to read".

BLIX must not be an end in itself. There is always a risk associated with index values, since they can be interpreted as absolute values. BLIX actually represents the average difficulty or ease with which a picture can be read. It also yields some very valuable information and detailed knowledge on the importance of individual picture variables. The ability of the receiver to study the contents of a word-picture message is likely to increase considerably if the word-picture is designed with this in mind. Knowledge of picture readability, i.e., our total ability to interpret and understand a visual message in terms of our per-

ception of the content, execution, and context of the visual, enables us to make a visual description.

In Norway Ertzgaard (1996) successfully used the picture readability index BLIX as one of the measurements in a major study of the use of text and pictures in textbooks. He calculated BLIX values for more than 1,300 pictures.

PRI

Lantz (1992) developed the concept of a photograph readability index in order to evaluate photos in textbooks. The instrument was designed for use in textbook adoption decisions. Lantz used methods from the fields of linguistics, reading, and cognitive psychology.

The initial phase gathers information on how a viewer perceives a photograph during an initial brief period, that is, at a first glance. The latter phase entails extended exposure to the photograph and endeavours to reveal how a viewer encodes information while being influenced by a caption. First glance fixations were assessed by projecting photographs for 1/2 second, after which subjects drew what they could remember about this display and completed an affective questionnaire. Exposing subjects to the image with caption assessed extended eye fixations, and then a cognitive questionnaire was completed. The revised instrument was useful in confirming subjective expert critique. However, the complexity of gathering this information would be prohibitive for many practical adoption applications.

Vrasidas and Lantz (1995), and Lantz (1996) further developed this concept of a photograph readability index into a picture readability index, which they labelled PRI. Here readability refers to the success of the image as defined by its objective or

caption. Images can be readable in the sense that they inspire cognitive and affective processing.

The PRI utilizes an interdisciplinary battery of methods adapted from the fields of cognitive psychology, linguistics, reading of text, semiotics, and visual literacy. The PRI is based on the theory that the processing of visual information comprises two main phases, related to the affective and the cognitive domains (Spoehr and Lehmkuhle, 1982).

Vrasidas and Lantz (1995) examined the initial and the prolonged stages in the perception of instructional photographs. In the first phase, affective or emotional impressions are formed as the viewer scans the image with rapid eye fixations. The viewer becomes aware of basic forms, begins to explore the image and starts to speculate about why it was created. The process may stop here, but it may also go on to a second step. For this phase subjects use a questionnaire with 77 questions in order to assess affective perception of the image.

The second phase of image processing is influenced by the context of the image, which is often provided by a caption. This phase is more cognitive and it includes processing of the caption as well. The viewer relates data from the first phase to his or her existing knowledge. Here the subject gets a second questionnaire with 80 questions dealing with cognitive processing. An image that stimulates a high degree of visual processing during both phases is considered very readable and gets a high PRI score. An image with low readability inspires reactions that do not go beyond initial first glance responses.

Vrasidas and Lantz (1995) concluded that the readability rating deriving from the PRI should be thought of as a classification attempt, and not a value judgement.

Readability of symbols

A message may be communicated to the receiver/s or interpreter/s with several different symbols. A symbol may be used to communicate several different messages. People have to learn the meaning of the important symbols within their own society. Therefore the information designer should:

- Use colour, position, size and shape.
- Use a combination of pictographs and words.
- Use realistic figures rather than abstract forms.

Many symbols are culturally biased and thus arbitrary to those from other cultures (Mangan, 1978). For example, when using a guidebook with symbols, we often have to look them up in a key in much the same way as we look up unfamiliar words in a dictionary.

The meanings of symbols have to be learned by the readers. Usually they are not naturally understood. Examination of guidebooks and magazines show that that: (a) A certain meaning is explained with several different symbols, (b) a certain symbol has several different meanings. Symbols are of special value and importance in maps. A good symbol is designed so it can be used in many different situations and in many contexts. Wogalter (1999, p. 94) concluded that warnings should contain certain elements:

- A signal word such as “Danger” and “Caution” that enables people to recognize that the message is a warning, that a hazard is present, as well as providing information on the hazard level (with “Danger” signalling more serious and probable injury than “Caution”)

- A description of the hazard, e.g. in the case of a no diving sign, a statement such as “Shallow water” provides information about the specific danger involved;
- A description of the consequences that could occur if the person fails to obey the warning’s directions, e.g. “You can be permanently paralysed”;
- The directions or instructions, i.e., the specific actions that should or should not be done, e.g. “No diving”.

Readability of maps

Maps must have good readability. Therefore the information designer should:

- Restrict the number of visual symbols on maps.
- Keep it as simple as possible.
- Be consistent! Inconsistencies will confuse the readers.

Traditional maps are static with a fixed scale and printed captions and map symbols. The functionality of maps has been greatly advanced by technology. Computerised *dynamic* and *interactive* maps are commercially available. By applying different layers a digital map can be adopted for specific purposes. It is possible to decrease and increase the scale and to move over and focus on different areas. In-car global navigation satellite systems are computerised maps with route planning and facilities for advice.

Symbols are of special value and importance in maps. However, symbols have to be learned by the readers. The way in which different visual variables are combined has greater importance than how the variables are comprehended (Bertin, 1967; Baudoiun and Anker, 1984). Using too many visual vari-

ables at the same time makes map reading more difficult. When several variables are used simultaneously the hierarchy of visibility is important. The largest symbols are always perceived first. *Size is more important than form and colour*.

Brodersen et al (2001, p. 9) and Stigmar (2010, p. 145) proposed that the following three types of measures can be used in order to quantify how "good" a map is:

1. The time that is needed to solve the task (quick–slow).
2. The behaviour used while solving the task (certain–uncertain).
3. The percentage of correct answers (right answers–wrong answers).

Readability of colour

Colours that are used in information materials must have good readability. Therefore the information designer should:

- Use colour to emphasize or to play something down.
- Use colour to show differences or similarities.
- Use colour to help readers recall information and to find things.

When colours of equal intensity are compared, the most visible hues are white, yellow, and green–in that order. The least visible hues are red, blue, and violet. Yellow is a powerful colour because of its luminosity. It is especially powerful when combined with black.

The McDonald symbol exists in many sizes from very small to very large.

Graphic symbols often make use of bright colours to intensify their meaning–in fact in some instances a change of colour creates a diametric change of meaning. Common hues in graphic symbols are pure yellow, red, blue, green, white and black, or combinations of the same. Unfortunately, red and green are quite often used as discriminating colours in symbols and in warning signs. Since many colour-blind people perceive red and green as grey colour can only be used to code the information redundantly. Colour may be combined with shape, and position, or with both, which is often seen in traffic signs. Complementary colours contrast, and they provide a warm–cool effect.

Female and male subjects showed no differences in reading efforts of different colour combinations (Pettersson, 1993). Furthermore there was no difference between colour blind (red-green) users and users with normal vision. Colour coding improves attention, learner motivation, and memory (Dwyer, 1994). Subjects dislike the use of more than three or four text colours on the same page, screen, or slide. For some learners and for some educational objectives, colour improves the achievement of the learners. However, in some cases the added cost of colour may not be justified (Dwyer, 1972).

Providing emphasis

Emphasis is used to attract or direct attention or dramatize certain points within a visual. A dark dot in a light field or a jog in a line is both examples of emphasis. The contrast of the dark area against the light background attracts attention to the dot. The more dots, the lower the degree of contrast and the less effective the emphasis. Many dots form a pattern of light and dark areas that compete with each other. Neither shade dominates nor demands more attention. The more competition for attention, the less effective is the emphasis.

Many different elements in a visual can cause emphasis. Light against dark, colour against no colour, detail against no detail, change in size, arrows, implied motion, circles or ovals around objects, stars, shaded areas, tonal contrast, isolation, complexity, directionality, line drawings in photos, words, position or placement of elements, line intersections, or any other unexpected change or variation out of context will create emphasis. Furthermore, emphasis on the message is achieved by reducing the number of details in the picture to those that are really essential.

Emphasis is achieved by reducing the number of details in the picture to those that are really essential. Many different elements in a visual can cause emphasis. Such examples are:

- Areas of colour (Mijksenaar, 1997),
- Areas of shading (Mijksenaar, 1997; Pettersson, 1989),
- Arrows (Beck 1984; Hartley, 1987; Jonassen and Kirschner, 1982; Lamberski & Dwyer, 1983; Mayer, 1993; Pettersson, 1989; Winn, 1989),
- Change in size (Pettersson, 1989),

- Colour (Winn, 1993; Wogalter, 1999),
- Complexity (Pettersson, 1989),
- Directionality (Pettersson, 1989),
- Imbalance (Fleming & Levie, 1978),
- Implied motion (Pettersson, 1989),
- Isolation (Pettersson, 1989),
- Letters in pictures (Pettersson, 1989),
- Light against dark (Pettersson, 1989),
- Line drawings in photos (Pettersson, 1989),
- Line intersections (Pettersson, 1989),
- Position or placement of elements (Pettersson, 1989),
- Reducing details (Pettersson, 1989),
- Repetition (Mayer, 1993),
- Stars (Pettersson, 1989),
- Words in pictures (Pettersson, 1989).

Inappropriate use of graphical elements may direct learner attention away from essential learning cues and depress subsequent achievement. To avoid disinterest and boredom, we should use varied methods for emphasis. Explanatory words, numbers, or other symbols should be incorporated into the picture as reading aids when this facilitates comprehension and learning. These aids must not then be distracting, large, or ugly. Simple styles and fonts are more easily read than complex ones. Symbols are of special value and importance in maps.

Relationships, moods, sound, and movements can be conveyed in a picture with the aid of signs and symbols. However, symbols have to be learned by the readers. Usually they are not naturally understood (Pettersson, 1993). Especially in developing countries, symbols must be introduced slowly and patiently.

Letters of the alphabet, numerals, lines, arrows, circles, and other symbols or markings can be added to a picture for the purpose of enhancing image content and focusing attention to specific parts of the image and links to the caption. We should avoid super-imposition of text on a picture image. This usually impairs our ability to absorb the contents of both the text and the picture.

In audio-visual materials, such as slides, filmstrips, and screen presentations, lettering must be considered carefully. Fifteen to twenty words on a slide are maximum for effective communication. Letters should be medium to medium-bold. Lettering height should be no less than one twenty-fifth the height of the artwork to be transferred. Generally speaking, lower-case letters are more legible than capitals.

A special area of emphasis is the design of *signs* and *symbols*. It must be possible to see warning signs in degraded conditions such as low illumination, smoke, or fog (Lerner & Collins, 1983). Warning signs must have adequate reflectance and good lighting (Sanders & McCormick 1993). The choice of colour depends on the environment in which the warning sign is placed (Young, 1991). Warning signs must have a high contrast relative to their background (Barlow & Wogalter, 1993). Informative words shall be used for signals such as “Danger”; for descriptions of a hazard such as “Shallow water”; and for specific actions that should or should not be performed (Dewar, 1999; Wogalter, 1999), such as “No diving.”

Linguistic combinations

Different combinations of linguistic expressions are usually employed in mass communications. For example, a textbook or a newspaper generally utilizes both printed words and pictures. A TV program employs words and images and sounds such as music. Interesting effects can be produced by the combination of various linguistic expressions, thereby heightening interest and attractiveness. We get more interested in the material and pay attention to it.

The results of several experiments show that learning is maximized when the contents of visual, audio, and print channels are on the same level. Conveying information through both verbal and visual languages makes it possible for learners to alternate between functionally independent, though interconnected, and complementary cognitive processing systems. The cited categories yield numerous ways of combining spoken and written language, sound effects and music, symbols and pictures when producing representations of reality. We have no designations for most of these combinations, and the designations we do have are often misleading. AV or audio-visual are common designations illustrating the problem. You never know exactly what is meant by the term "AV." It may refer, e.g., to the use of slides or to slides with audio cassettes. The slides may contain images with pictorial content or images with verbal content or both. Braden and Beauchamp (1986) make a distinction between "reader slides" and "picture slides".

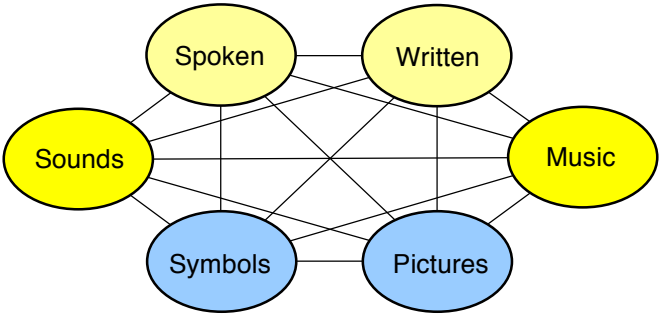
More distinct, specific designations are necessary to any serious discussion of linguistic expressions and different kinds of representations. There is no practical need for designations covering all the combinations possible. However, we should at

least be able to distinguish between the categories "spoken language" and "written language" in the "verbal language" category. Sound effects and music could be placed under the heading "audial language." Symbols and pictures could be referred to as "visual languages." This would leave a smaller, more easily managed number of combinations.

In verbal languages, spoken language or "audial verbal" (or "aural verbal") can be designated oral. Written language or "visual verbal" or "graphic-verbal" may be designated as lexigraphic. Combinations of these may be referred to as oral-lexigraphic. Examples of such representations are texts recited in a theatre, radio program, or on audiotape. In audial languages both sound effects and music are audial (or aural). Examples may be found in radio programs and audiotapes. In visual languages both symbols and pictures are visual. Symbols are used, e.g., for traffic signs. Pictures can be found almost everywhere, usually in combination with verbal and/or audial languages. Paintings, drawings, and other objects of art often are stand-alone objects. (Paralinguistic visual expressions are not discussed here.)

Combinations of verbal language + audial language can be designated audio-verbal. This designation can be used in describing representations on radio, audiotapes, records, and compact discs. Verbal language + visual language can be designated verbal and visual and sub-divided into oral-visual (e.g., a filmstrip with a spoken commentary) and lexi-visual (frequently found in books, magazines, and other printed matter). Audial language + visual language can be designated audio-visual. Many artistic slide-tape shows and multi-image presentations employing images, music, and sound effects belong to this cate-

gory. Verbal language + audial language + visual language may be designated verbo-audio-visual. Motion pictures, television, and video programs belong to this category. Audio-visual or verbal and visual films, TV shows, and video programs are also possible and sometimes necessary.



Many combinations of linguistic expressions are possible. (Pettersson, 1989)

However, this theoretical model may not be practical to use in everyday life. Based on how the verbal information is presented to the receivers, we can distinguish between two forms of verbal and visual information. We read text in lexi-visual representations, and we listen to speech in audio-visual representations (the term audio-visual is used here in the traditional sense as a designation for sounds and visuals).

When we receive a verbal and visual message, it may be audio-visual, lexi-visual, or multi-visual. We often are rather quick to form a mental pre-understanding, which influences our perception of the message. We do expect to find different kinds of contents in a newspaper, a business magazine, a book for small children, a textbook in chemistry, a non-fiction book

about dog care or gardening, in the news or in the weather reports on TV, etc. It may in fact be rather hard to bypass such pre-understandings and reach to the "real or true" understanding of the message. When we see a realistic picture we expect to find an informative real-world story content. When we see a cartoon we expect to find a narrative text and an imaginative content.

A page in a textbook should always be designed as a fully integrated verbal and visual message. To achieve harmony and avoid conflicting interpretations and confusion, it is important that the verbal and the visual parts of the message are created in corresponding "styles" and kinds of content. We often see the pictures before we read the text (Lidman & Lund, 1972). A heading to a text gives the reader a pre-understanding of the contents of that specific text.

In many situations pictures may function like "headings" to the text, helping the reader to form pre-understandings. As seen earlier, an image is interpreted in different ways depending on the assignment. An immediate image interpretation is handled on a low cognitive level. An analytic image interpretation needs high cognitive level activities. When we see pictures on a printed page, we obviously very quickly make up a mental pre-understanding of the style and kind also of the text as well as a pre-understanding of the complete message on that page or in that program. We may decide not to read the text at all and leave the page. If we decide to read the text, then reading the text and reading the picture make it possible to create an understanding of the verbal and visual message contents.

Characteristics of visual language

To be able to produce a visual message in any medium it is important to understand the major characteristics, the possibilities and the restrictions, of visual language and of pictures. We need to know how visual languages are constructed, how they are perceived, and how they differ from verbal languages. Major characteristics of visual language are listed below in the form of short summary statements. These statements are based on references in the literature, and on my own findings.

Properties of visual language

1. Visual languages have "analogue coding" employing combinations of basic graphic elements (dots, lines, areas, and volumes) for depicting reality. A given set of basic elements can be combined to form completely different images. (Pettersson, 1987)
2. Visual languages attempt equivalence with reality. Visuals are iconic. They normally resemble the thing they represent. Meaning is apparent on a basic level, but the visual language must be learned for true comprehension. (Pettersson, 1989)
3. Images and visual language speak directly to us in the same way experience speaks to us: holistically and emotionally. (Barry, 1998)
4. Factors in visual language are related to criteria such as the content and execution of a visual, its context and format, and the subsequent perception, learning, and memory. (Pettersson, 1983b)
5. Content is more important than execution, context, and format. Pictures have a strong emotional impact. (Pettersson; 1987, 1989)

6. Factors in visual language have both functional and semantic properties. (Pettersson, 1983a)
7. The same intended theme or subject may be expressed through many different pictures. (Pettersson, 1986a, 1986b)
8. The effectiveness of a visual depends on the medium, on the type of information, and also on the amount of time learners are permitted to interact with the material. (Dwyer, 1972)
9. All types of visuals are not equally effective. Line drawings are most effective in formats where the learner's study time is limited. More realistic versions of artwork, however, may be more effective in formats where unlimited study time is allowed. (Dwyer, 1972)
10. No pictorial image gains the status of a "statement," unless an explicit reference is made to what it is supposed to represent. (Gombrich, 1969)

Development of visual language abilities

1. Visual language abilities develop prior to, and serve as the foundation for, verbal language development. (Moriarty, 1994; Reynolds Myers, 1985)
2. Because children developmentally cannot or do not pay attention to factual information in advertising–but rather to peripheral cues such as colour and imagery–they tend to process advertising not through logical assessment, but through their emotions. (Barry, 1998)
3. Development of visual language abilities is dependent upon learner interaction with objects, images, and body language. (Reynolds Myers, 1985)
4. There seem to be no major difference between gender in interpretation of image contents. (Dwyer, 1972)

5. Comprehensive school students have a very poor pictorial capability. They are poor at reading and understanding pictures. They are also poor at expressing themselves with pictures. (Backman, Berg & Sigurdson, 1988; Eklund, 1990)
6. Both students and teachers have to learn how to read, how to create and how to use visuals. (Pettersson, 1990)
7. People who have not learned to read or write do not necessarily look at pictures in the order intended. It often proves helpful, as messages are being tested, to ask several groups of people to arrange the individual message into a sequence that seems most logical to them. (Zimmermann & Perkin, 1982)

Perception of visual messages

1. There are major differences between the concepts "seeing," "looking," and "reading." (Pettersson, 1986a)
2. It may take only 2-3 seconds to recognize the content in an image (Paivio, 1979; Postman, 1979), but 20-30 seconds to read a verbal description of the same image (Ekwall, 1977; Lawson 1968) and 60-90 seconds to read it aloud (Sinatra, 1986). In verbal and visual languages prior experience and context are very important to the perception of contents.
3. The pattern for eye movements and fixations depends on what we wish to see, or are told to see in a picture. (Yarbus, 1967)
4. Perception of two- or three-dimensional representations entails fast, parallel, simultaneous, and holistic processing. (Gazzaniga, 1967; Sperry, 1973, 1982)

5. The same visuals are not equally effective for learners in different grade levels, and for learners with different prior knowledge. (Dwyer, 1972)
6. Certain colours have different meanings in different societies. (Zimmermann & Perkin, 1982)
7. It is not likely that there will be just one, but several equally good options available for achieving satisfactory communication. The design of a picture can be changed a great deal without any major impact on the perception of the image contents. (Pettersson, 1986b)
8. There is a large degree of perceptual constancy. We can view a symbol or a picture from various distances and various angles and still get the same perception of the image content. (Pettersson, 1989)
9. Persuasion tends to be accomplished in both children and adolescents almost exclusively through imagery. (Barry, 1998)
10. Seeing is to believe. Most people believe that pictures tell the truth. (Lefferts, 1982)
11. Graphics can help readers see and comprehend complex patterns. (Horton, 1991)
12. Stylized and "simple" pictures are more effective than complex pictures. (Melin, 1999)

Understanding of visual language

1. We are able to differentiate between "immediate" and "analytical" understanding of pictures. (Pettersson, 1987)
2. Different assignments may cause different interpretations of image contents. Some assignments cause interpretation of

image contents on a low cognitive level, and some on a high cognitive level. (Pettersson, 1987)

3. Different people may understand and describe a picture in different ways. (Pettersson, 1987)
4. Comprehension is higher when a whole person, rather than some part of the body, is portrayed in the picture. (Zimmermann & Perkin, 1982)
5. Pictures of abstract subjects are understood in considerably more varied ways than pictures with concrete subjects. Abstract subjects are described in concrete terms. (Pettersson, 1985)
6. Visuals are cultural products shared by individuals (Moriarty & Rohe, 1992).
7. Visuals are understood within individual people's frames of reference (Singer, 2010).
8. Visual logic is "associationistic," and it continually works to make sense of disparate elements by weaving them together into a kind of visual story that speaks most clearly to the emotions. (Barry, 1998)
9. Even simple pictures may cause many different associations. (Pettersson, 1994)
10. Each receiver will place available information in a wider, expanded, "personal" context. (Pettersson, 1991, 1994)
11. Receivers are apparently capable of sensing far more information than is explicitly displayed in a given picture. (Pettersson, 1991, 1994)
12. Picture readability is positively correlated with both the aesthetic rating and usefulness in teaching. The aesthetic rating and assessed usefulness in school were also strongly correlated. (Pettersson, 1983c)

13. How we actually create meaning is an area where a lot of research is still needed. (Pettersson, 1987)

Memory for pictures

1. Visual memory is very fast. (Beaver, 1994)
2. Memory for pictures is superior to memory for words (Branch and Bloom, 1995; Paivio, 1983). This is called the "pictorial superiority effect".
3. Memory for a picture-word combination is superior to memory for words alone or pictures alone. (Adams & Chambers 1962; Haber & Myers, 1982)
4. Visual rehearsal allows the learner to process information simultaneously at several levels. (Dwyer, 1994)
5. Emotionally charged pictures may improve motivation for reading and thus improve the memory. (Melin, 1999)

Combined verbal and visual presentations

1. Any message may be conveyed using verbal and visual representations. (Pettersson, 1993)
2. There are always several opportunities to convey a message. (Pettersson, 1986b)
3. Text-relevant pictures facilitate learning from reading prose. (Levin et al., 1987)
4. When illustrations provide text-redundant information, learning information in the text that is also shown in pictures will be facilitated. (Levie & Lentz, 1982; Melin, 1999).
5. When illustrations are not relevant to prose content they can have a negative effect. (Evans, Watson & Willows, 1987; Furnham & Williams, 1987; Gunter, 1980; Levie & Lentz, 1982; Levin et al., 1987; Massoumian, 1989; Melin, 1999b;

Pettersson, 1989, 1993; Rieber, 1994; Sims-Knight, 1992; Sung-Hee & Boling, 2010; Winn, 1993)

6. Texts and pictures are completely different languages that complement each other. (Melin, 1999; Pettersson, 1985)
7. Both text and images can be designed and perceived in many different ways. (Pettersson, 1983c)
8. The possibilities for combining texts and pictures are virtually unlimited. The interplay between text, picture, and graphic form needs to be studied thoroughly before optimal combinations can be found. (Pettersson, 1993)
9. To get maximum impact from a visual, the writer or the presenter should introduce the visuals before presenting it. We create a "pre-understanding" of how a picture may be interpreted, based on the context in which the picture is shown. (Pettersson, 1989)
10. Most pictures are capable of several interpretations until anchored to one by a caption. (Barthes, 1977)
11. Pictures that will be used for information purposes should always be supplied with captions. This is the only way to assure that information conveyed by these pictures is clear and unambiguous. Even simple pictures need plain captions for the contents and presentation to be conveyable in verbal form. (Pettersson, 1985, 1986b, 1987, 1990)
12. Captions should be written with great care. They heavily influence our interpretation of image content. To a large degree readers see what they are told to see in an image. (Pettersson, 1987)
13. If pictures are not adequately discussed and explained, they will probably not be properly understood. (Zimmermann & Perkin, 1982)

14. Learners are most able to build connections between verbal and visual representations when text and illustrations are actively held in memory at the same time. This can happen when text and illustrations are presented in close connection on the same page in a book, or when learners have sufficient experience to generate their own mental images as they read the text. (Mayer et al., 1995)
15. In Nigeria "...most primary and secondary school pupils want to see visual illustrations in their textbooks because it helps them to learn more effectively. All the teachers also believe that visual illustrations are vital to teaching and learning at the primary and secondary school levels." (Ajibade & Elemi 2012, p. 170)

These characteristics of visual language define the framework for creation of clear messages and may be used as guidelines for such productions.

Picture quality

A question such as "what is good or poor picture quality?" may seem trivial. But there is no widely accepted definition for "picture quality," nor any unambiguous or sufficiently comprehensive measure of this parameter. Any visual produced to convey information must obviously contain the information to be conveyed. Such a visual's content, execution, context, and format elicit a response, a perception, and possibly subsequent learning and memory. The information producer should produce representations in such a way that perception, on the average, is optimized.

Good picture quality can be defined as the degree of coincidence between the sender's and receiver's subjective perception of the picture and the reality (external or internal) represented by the picture. According to this definition, the concept "picture quality" is related to the entire communications process.

Reading value

A visual is well worth reading and has a high *reading value* when the content is interesting to the reader from a functional and/or from a semantic point of view. Reading value is very subjectively dependent on the reader's degree of interest in the message. Each group of readers selects information material on the basis of her or his personal preferences. What is interesting for one person may be perceived as boring by another person. The same message may be interesting at one instance but uninteresting at another occasion.

The *aesthetic value* of a message is how the intended receivers perceive it with respect to beauty. Aesthetics aims to establish the general principles of art and beauty, harmony and proportion. Material with a (sufficiently) pleasing aesthetic form has greater potential for conveying a particular message than does un-aesthetic material.

The *legibility* is mainly depending on the execution of the visual. The *readability* is mainly depending on the functional properties of the visual.

Measuring picture properties

There are several ways of "measuring" picture properties. These "tools" can be used before the original is finished, before the technical production, and after the actual publication of the images.

Before the original

A picture description can be drawn up on the basis of our knowledge of man's ability to interpret and understand a visual in terms of perception, contents, execution, context, and format. A "picture description" is a depiction in words and sketches of a visual that does not yet exist.

Before technical production

Draft versions and also alternative versions of information materials may be tested to determine whether or not the visuals are attractive and appealing, communicate the intended information or message, and are acceptable to the intended audience.

OBS and reading value ratings

Larssen and Skagert (1982) employed two "preview tests" in order to assess reader response to as yet unpublished advertisements. A simple interview test provides a good forecast of future OBS (observation) and reading value ratings. The two central questions were (p. 28):

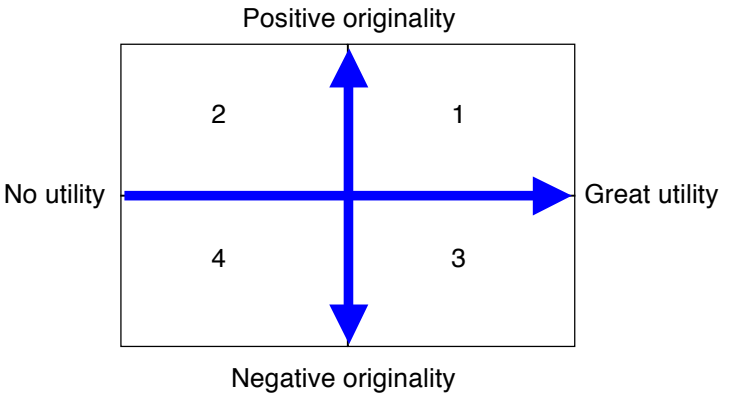
1. If you encountered this ad in a newspaper, would you stop to look at it?
2. If you encountered this ad in a newspaper, do you think you would read any of the text in it?

When numerous subjects respond affirmatively, an ad can be expected to receive high OBS and reading value ratings. The opposite is also the case, i.e., if numerous subjects respond negatively.

Utility/originality rectangle

The second preview test entailed assessment of ads according to the concepts "utility" and "originality." First, the extent to which the reader derived any benefit from reading or taking a closer look at an ad was rated. The rating scale ranged from "no utility" to "great utility." The degree of execution originality was then assessed.

Readers usually subsequently rated ads that had been assessed with positive originality and great utility (field 1 in the "utility/originality" rectangle) were as "good ads." Publication of an ad with negative originality and little or no utility (field 4) is virtually pointless.

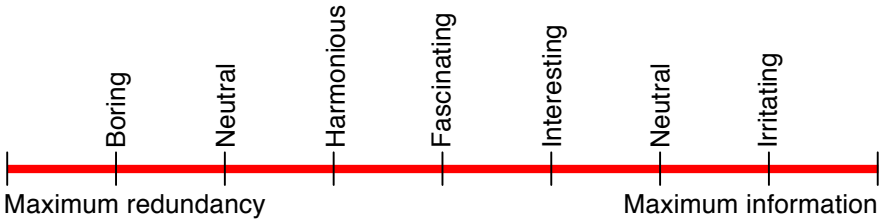


This is the "utility/originality" rectangle.

Redundancy/Information

Berefelt (1976) suggested that experience grows in steps in the power field lying between events previously observed and not observed, between the familiar and unfamiliar, and between banality and originality. The greater the amount of information supplied (the less the redundancy), the greater the amount of energy needed by the information recipient in order to register and comprehend the new data. Berefelt used a horizontal line with maximum redundancy and maximum (new) information as the line's theoretical end points to describe registration and processing of stimuli.

Maximum redundancy elicits complete familiarity with the material, e.g., a picture. Maximum information elicits a total inability to comprehend the signals. Our perception of different pictures probably falls between these two extremes. Berefelt assigned seven proportionally spaced perception positions from an infinite number of possible positions on the line. These perceptions, from a high degree of redundancy to a high degree of information, were referred to as "boring" (unpleasant), "neutral," "harmonious" (pretty), "fascinating" (nice), "interesting" (exciting), "neutral," and "irritating" (unpleasant).



This is the Redundancy/information line.

A picture creator who is very familiar with her/his target group can easily ensure that redundancy/information in a picture is on a level relevant to the picture's aim. The redundancy factor provides the picture creator with an opportunity to relate viewer perceptions to picture contents.

Redundancy/Information/Communicative impact

A refinement of Berefelt's ideas could result in a model that also includes consideration of the communicative impact of pictures. Our perception of a picture probably affects the picture's communicative impact. Pictures found to be boring or irritating are likely to have poor communicative impact. However, a picture perceived to be "wonderfully fascinating" is bound to be very good in communicative respects. The fact that the communicative impact of a given picture may differ for different people must obviously be kept in mind. Different people also respond to the redundancy factor in different ways depending on, e.g., previous experience, social factors, and cultural circumstances. For these reasons, plus the fact that identification of the degree of both redundancy/information/communicative impacts may be difficult, the model may be unsuitable for use in practical work.

Interest/Perception

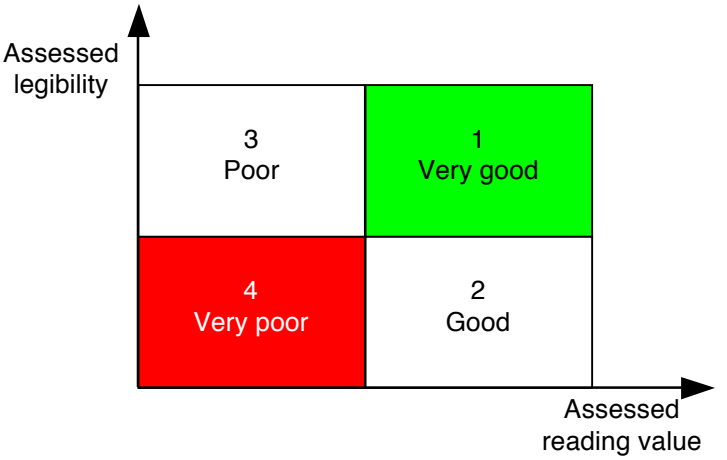
In a world in which it is becoming increasingly difficult to avoid unsolicited information and, at the same time, increasingly difficult to find information we really wish to find, our interest in material may be decisive to the way in which we perceive that material. Interesting material arouses our emotions to a greater extent than material we regard as boring. The degree of interest

can be described with a rating between “no interest at all” and “maximum interest.” So the interest factor is one way to define the viewer’s relationship to picture contents. When interest is zero, our emotional response is negative or, possibly, indifferent. Emotional response increases as the interest factor increases and becomes increasingly positive. However, a given picture may evoke different emotional responses in different people, even when they share a common degree of interest in the picture. Different people also perceive the interest factor in different ways. As is the case with the Redundancy/Information/Communicative impact model, the Interest/Perception model may be hard to use in practical work.

The Legibility/reading value rectangle

A picture can also be rated according to legibility and reading value. First, the extent to which the picture is readable for the intended reader is rated. Does the picture have considerable reading value and interest or does it have poor reading value and little interest? The picture’s legibility is then rated. Is the picture distinct and easily read, or is it indistinct and difficult to read with a view to its execution?

An informative picture with positive reading value and legibility is probably “very good.” A picture is “good” if it is readable but difficult to read. The picture is “bad” if it has limited reading value and is easy to read but “very bad” when it has poor reading value and is also difficult to read. Initial experiments suggest that a preview test of this kind could prove to be very useful. The BLIX-reading-scheme may be used in order to measure picture readability



This is the "legibility/reading value" rectangle.

After publication

A picture analysis, i.e., a descriptive rating of a picture, and various practical tests can be carried out to determine whether or not an information disseminator's intentions are accurately realized. The results of these tests can be used for revision of the picture description that, in turn, could result in even more effective informative material.

Picture analysis

A picture analysis can comprise a description and, possibly, a rating of picture language, contents, execution, context, format, medium, distribution method, sender, receiver, objectives, etc. Different sets of questions can be used in picture analysis depending on the objective of the analysis. The following questions may be useful in a brief, general analysis:

- *Visual language*. Is the visual language clear and distinct? Is the visual language adopted to the culture and to the audience? Is the picture's "meaning nucleus" obvious? Does the picture contain a lot of insignificant information?
- *Content*. What is (are) the subject(s) in the visual? Is (are) the subject(s) easy to understand? What are the relationships of the different subjects? Is one part of the picture dominant over the others and why? Is the picture a typical or a non-typical example of the subject? What is the degree of realism and detail? What is the degree of credibility? How are motion, time, sound, and emotions expressed?
- *Execution*. What type of visual is it? Is the subject large and clear? What is the shape, size, colour, and contrast? How is the composition in terms of organization, centres of interest, and balance? What is the depth, picture angle, and picture height? What is the technical quality like? Does the picture have symbols and explanatory words?
- *Context*. What is the context? Is there a caption, texts, other pictures, or sound in connection with the picture? How is the layout done?
- *Picture readability*. What is the picture readability index?
- Medium. In which medium is the picture used? Is the picture used in mass-media, in group-media, or in personal media?
- *Distribution*. How is the distribution organized?
- *Sender*. Who is (are) the sender(s)? Who is (are) the producer(s)? Are the views of the sender important to the use of the picture?
- *Receiver*. Who is (are) the receiver(s)? Do the receivers form a homogeneous group? Is the group small or large?

- *Aims*. Why has the picture been produced? Has the picture been produced for advertising or propaganda? Are "hidden" intentions imbedded in the image?
- *Impact*. Is the picture likely to have an effect on learning, human feelings, attitudes, or opinions? What impact is it likely to have?

The various preview tests can also be transformed into true readability tests. The results of these tests can also lead to revised picture descriptions.

Goldsmith (1980, 1984, 1986) offers an analytical model for illustrations. Her model consists of twelve elements that are formed by the interaction of four visual factors with three levels of communication. The four visual factors are: 1) unity, which refers to a single image location; 2) the spatial relationships between two or more images within a single picture emphasis; 3) the hierarchical relationships between images and text parallels; and 4) the relationship between text and picture. The three levels of communication are: 1) syntactic, which does not assume any recognition or identification of images; 2) semantic, which concerns the basic recognition of an image; and 3) pragmatic, which reminds us that readers will differ in age, sex, education, and so on.

- *Syntactic unity* is an acknowledgement that an image exists. A minimum requirement is that the bounds of each image should be discernible.
- *Semantic unity* is the possibility to identify an image.
- *Pragmatic unity*. The characteristics of the viewer can work for or against recognition of an image.

- *Syntactic location* refers to depiction of depth with the use of converging lines, etc.
- *Semantic location*. Known size of an object can indicate depth.
- *Pragmatic location*. The experience of the viewer is needed to resolve ambiguous details.
- *Syntactic emphasis* refers to the use of cues for attracting and directing the attention of the viewer.
- *Semantic emphasis*. The human face is of universal interest and attracts attention.
- *Pragmatic emphasis*. Various instructions may influence our perception of the image. This aspect also includes special interests of viewers.
- *Syntactic text parallels* refer to the physical/spatial relationship between pictorial and verbal signs.
- *Semantic text parallels* refer to distinguishing features of an object that serve to identify that object correctly. Here images and words are matched.
- *Pragmatic text parallels*. The interpretation of the message by the viewer.

Peterson (1984) has worked on an analysis of comic strips and has proposed the following model based on a semantic approach:

- An analysis of the storyline. Which hidden values do the figures represent? How are conflicts presented in the story? How are conflicts resolved? Are any myths created?
- An analysis of picture structure and meanings on both denotative and connotative levels. When characters conveying

meaning are interpreted, both internal and external context are taken into consideration.
- An analysis of the importance of balloon texts.
- A study of the location of emphasis in the communications process.

This should lead to identification of the comic strip's function, e.g., to be poetic or challenging. How is imagination employed? Is it in an emancipative, compensatory, or power-confirmative manner? Which attractive properties do the pictures have? Are there fascinating, aesthetic shapes? Do they play on any particular emotions, needs, or dreams? Which dialectic relationships prevail between the strip's design and receiver context?

Values and attitudes

Semantic differential scales in which the sender and/or receivers report how positively or negatively they respond to a given picture in overall terms or with respect to individual picture variables can also be employed in measuring how "good" or "bad" a picture is.

Semantic differential scales can comprise general attitude toward a picture (Bad–Good), aesthetic value (Ugly–Pretty), reading value (Uninteresting–Interesting), technical quality (Poor–Good), legibility (Hard to read–Easy to read), educational value (Slight–Great), and credibility (False–True). The combination of verbal and numerical scale steps makes possible statistical calculations of mean values, standard deviations, and confidence intervals. This makes the method suitable for large groups of subjects.

Observations
Producers of visuals for information may benefit from observing how receivers and "actual users" use information materials in normal situations. Observers could also interview "members of the audience" about how, why, and when they use visuals.

Photographic portrayals
An analysis of a photographic portrayal can examine positive versus negative depictions of individuals in photographs (Archer et al., 1983; Moriarty & Garramone, 1986; Moriarty & Popovich, 1991; Wanta & Chang, 2000). These authors have examined several variables that will influence our perception of individuals in photographs.

- *Camera angle*. An individual appears powerful if he or she is photographed from below with the photographer looking up at the subject. An individual appears less powerful if he or she is photographed from above (Moriarty & Popovich 1991).
- *Camera placement*. Photographs showing a subject straight on are more positive than those showing a subject from the side and much more positive than those showing a person from behind (Moriarty & Popovich,1991).
- *Eyes*. Individuals shown with closed eyes are viewed more negatively than those shown with open eyes (Moriarty & Popovich, 1991).
- *Facial expression*. Individuals smiling are viewed as positive and individuals frowning are viewed as negative (Moriarty & Popovich, 1991).
- *Framing*. The larger a person's face appears in a picture, the more positively our perception of that individual is. A close-

up headshot of a person is more positive than a photo taken from a distance (Archer et al., 1983).

- *Head position*. Individuals looking straight at a camera look more in control than those individuals looking up or to the side. Individuals look least in control if they are looking down (Moriarty & Popovich, 1991).
- *Posture*. Individuals are viewed more positively if they are shown walking, running or moving. People standing are viewed more positively than if they are motionless (Moriarty & Popovich, 1991).
- *Purpose of photo*. The purpose of a photo is important for our perception of the person depicted (Moriarty & Garramone, 1986).
- *Secondary subjects*. Other people in a photograph, the context of the individual, may influence how people view a photograph (Wanta, 2000).

Visual analysis

In "visual analysis" the term "modality" means how real a representation should be taken to be (Machin, 2007, p. 46). Photographs that bear a truthful witness to an event have got "high modality." These images reflect what we would have seen had we been there. Modality can be decreased or increased.

According to Machin we can apply "modality scales" to assess the "modality configuration" for an image. These scales concern the degrees of articulation of background, colour modulation, colour saturation, depth 1, depth 2, detail, light and shadow, and tone (Machin, 2007, p. 57).

- *Degrees of articulation of background*. This is a scale ranging from a blank background, via lightly sketched in- or out-of-focus backgrounds, to maximally sharp and detailed backgrounds.
- *Degrees of articulation of colour modulation*. This is a scale ranging from flat, un-modulated colour to the representation of all the fine nuances of a given colour.
- *Degrees of articulation of colour saturation*. This is a scale ranging from black and to white to maximally saturated colours.
- *Degrees of depth articulation 1*. This is a scale ranging from maximum depth articulation to simple overlapping of objects.
- *Degrees of depth articulation 2*. This is a scale ranging from the absence of any depth to maximally deep perception, with other possibilities (e.g. simple overlapping) in between.
- *Degrees of articulation of detail*. This is a scale ranging from the simplest line drawing to the sharpest and most finely grained photograph.
- *Degrees of articulation of light and shadow*. This is a scale ranging from zero articulation to the maximum number of degrees of "depth" of shade, with other options in between.
- *Degrees of articulation of tone*. This is a scale ranging from just two shades of tonal gradation, black and white (or a light and dark version of another colour), to maximum tonal gradation.

Technical quality

Obviously, the technical quality of a visual should be "good" and tailored to the specific medium. A printed picture should be

matte and distinct, not blurred, overly glossy, or dazzling. Resolution should be sufficient for the reproduction of the desired details. Remember that fine details in the texture of a visual disappear in the dot screen structure of the printed image. Even more detail is lost in a television image, or on a computer visual display. Poor technical quality is far too common in information materials. The result of most of the previous work on visualization and making originals can easily be destroyed by a single error in the making of the master or in the actual production of the copies.

Functions of visuals

Pictures may have many different functions. Generally speaking it is not possible to rank the different types of visuals. Often the type of visual that should be used must be determined in each individual case with a view to various demands on the picture and the prevailing budget framework. From a theoretical point of view, a visual can possess many different functions and effects or combinations of functions and effects. Thus, a distinction can be made between symbols and pictures.

In western civilizations a symbol is often something that "represents" something (Lee, 1959). We "apply" words to things or names to persons. These "signs" stand for the things to which they have been applied. However, Agrawal et al. (1987) pointed out that in the context of the ancient Indian civilization the symbol is not a representation. A symbol is a concretization of reality having intrinsic power of its own. It is a part within the whole belief system, and a link between the past, the present, and the future. Signposts, traffic signs, and labels are examples

of symbols. They are unambiguous by convention. We agree and decide on their meaning.

All pictures are representations of reality. The "reality" of a printed page does not exist in real life, other than on the page. As is the case for other kinds of representations, pictures are always open to different interpretations by different people at different times. Some pictures are open to many interpretations, others to only a few. Cochran (1987) distinguishes between actual events and objects, iconic re-presentations, and arbitrary representations. Examples of iconic representations are film and TV-images, still photographic pictures, and realistic artwork. Symbols, signs, computer graphics, and words are all examples of arbitrary representations. Here no cues from actuality are left.

Still pictures

We know that visuals are perceived much more rapidly and readily than text (Fleming & Levie, 1978, 1993; Sinatra, 1986). Lester (1995, p. 73) noted that: "Visual messages are a powerful form of communication because they stimulate both intellectual and emotional responses–they make us think as well as feel." Many papers have suggested various roles, functions, objectives and purposes for the use of illustrations–often without a great deal of evidence to support the suggestions.

Mayer (2009) analyzed textbooks for sixth grade science and found that an "overwhelming majority of illustrations served no important instructional purpose: 23 percent were decorational and 62 percent were representational" (pp. 236-237). According to literature in the areas of instructional mes-

sage design, visual literacy, and visual communication visuals may be used in order to:

- *Activate* prior knowledge (Clark & Lyons, 2004).
- *Add* aesthetic appeal (Clark & Lyons, 2004).
- *Add* concreteness to prose (Levin, Anglin & Carney, 1987).
- *Add* humour (Clark & Lyons, 2004).
- *Adopt* a new attitude (Heinich, Molenda & Russell, 1982).
- *Adorn* something (Selander, 1988).
- *Advance* organizing of text comprehension (Bernard, Petersen & Ally, 1981).
- *Aid* credibility (Fleming & Levie, 1978).
- *Analyze* content (Brumberger, 2011; Burns, 2006).
- *Anchor* an image in memory (Moriarty, 1991).
- *Appeal* to the eye (Duchastel, 1983; Levin, 1981).
- *Argument* (Mral & Olinder, 2011).
- *Assist* in concept development (Fredette, 1994).
- *Associate* the product with certain symbols and lifestyles (Moriarty, 1991).
- *Attract attention* to a given material or a given subject (Duchastel, 1978; Duchastel & Waller, 1979; Evans, Watson and Willows, 1987; Heinich, Molenda & Russell, 1982; Holliday, 1980; Keller & Burkman, 1993; Levie & Lentz, 1982; Levin, Anglin & Carney, 1987; Lester, 1995; Peters, 1978; Pettersson, 1993; Wileman, 1993).
- *Be decorational* (Mayer, 2009).
- *Be effective* (Keller & Burkman, 1993).
- *Beautify* something (Selander, 1988).
- *Break up* longer blocks of text and make the pages more appealing (Duchastel, 1978).

- *Bring* inaccessible processes such as historical events or microscopic changes to the audience (Moriarty, 1991).
- *Bring* into the classroom inaccessible processes, events, situations, materials and phase changes in either space or time (Dwyer, 1978).
- *Build* mental models (Clark & Lyons, 2004).
- *Build* new experience (Fredette, 1994).
- *Build* prior knowledge (Clark & Lyons, 2004).
- *Carry* the proof of a presentation (Griffin, 1994).
- *Change* a viewer's attitude (Lester, 1995).
- *Clarify* opinions (Fredette, 1994).
- *Clarify* oral and printed communication (Dwyer, 1978).
- *Clarify* passages in a text (Levin, Anglin & Carney, 1987).
- *Clarify* pieces of an abstract, language-based concept (Ramadas, 2009; Wileman, 1993).
- *Communicate* a message in an efficient way (Wileman, 1993).
- *Compare* (Fredette, 1994).
- *Compare* one image content with another (Hunter, Crismore & Pearson, 1987).
- *Comprehend* content (Burns, 2006; Lord, 1985; Ramadas, 2009).
- *Compensate* poor readers (Duchastel, 1978).
- *Construct* meaning (Burns, 2006; Felten, 2008).
- *Contrast* (Fredette, 1994).
- *Contrast* one image content with another (Hunter, Crismore & Pearson, 1987).
- *Contribute* to curiosity (Keller & Burkman, 1993).
- *Convey* an idea (Lester, 1995).

- *Convey* information to the reader or viewer (Dondis, 1973; Pettersson, 1989).
- *Convince* someone using factual information, persuasion (Lester, 1995).
- *Correct* misconceptions (Fredette, 1994).
- *Create* believability through realism (Moriarty, 1991).
- *Create* interest in a given material or in a given subject (Duchastel, 1978; Duchastel & Waller, 1979; Holliday, 1980; Levie & Lentz, 1982; Levin, Anglin & Carney, 1987; Pettersson, 1993).
- *Creation* of social contact with the receiver, phatic function (Peters, 1978; Van Aswegen and Steyn, 1987; both cited in Gaede, 1998).
- *Deceive* learners; aesthetically pleasing visuals may deceive learners about their instructional value (Dwyer, 1972).
- *Decode* content (Burns, 2006).
- *Decorate* something (Anglin & Carney, 1987; Clark & Lyons, 2004; Dondis, 1973; Fredette, 1994; Levin, Selander, 1988).
- *Demonstrate* product features (Moriarty, 1991).
- *Depict* an object in a realistic fashion (Clark & Lyons, 2004).
- *Depict* elements of the instructional content (Levin, Anglin & Carney, 1987).
- *Depict* reality (Pettersson, 1989).
- *Depict* situations and settings (Moriarty, 1991).
- *Designate* spatial orientation (Pettersson, 1989).
- *Develop* appreciation (Heinich, Molenda & Russell, 1982).
- *Discriminate* among facts (Heinich, Molenda & Russell, 1982).
- *Display* information (Fredette, 1994).

- *Dupe* an unsuspecting public through misleading or false information, propaganda (Lester, 1995).
- *Elaborate* the text (Hunter, Crismore & Pearson, 1987).
- *Embellish* the text (Hunter, Crismore & Pearson, 1987).
- *Emphasize* aural and printed instruction (Dwyer, 1978).
- *Encourage* the expression and clarification of opinions (Fredette, 1994).
- *Enhance* enjoyment (Levie & Lentz, 1982).
- *Enhance* the reality of a material for the reader (Smith and Smith, 1966).
- *Enrich* reading (Dale, 1969).
- *Establish* a mood (Moriarty, 1991).
- *Establish* a product personality (Moriarty, 1991).
- *Evaluate* learning (Fredette, 1994).
- *Evoke* aesthetic appreciation, poetic function (Peters, 1978).
- *Exemplify* something (Melin, 1986a; Pettersson, 1989).
- *Explain* difficult phenomena (Winn, 1993).
- *Explain* things (Pettersson, 1989).
- *Express* attitudes and intentions, expressive function (Peters, 1978).
- *Express* mood and tone (Brumberger, 2011).
- *Express* opinions (Fredette, 1994).
- *Express* the artist's feelings (Dondis, 1973).
- *Extend* curiosity (Peeck, 1987).
- *Facilitate* cognitive processes (Levin, Anglin & Carney, 1987).
- *Facilitate* discrimination and identification of relevant cues (Dwyer, 1978).
- *Facilitate* learner acquisition of information (Dwyer, 1978).

Facilitate learning from a text by enhancing comprehension and memory (Duchastel, 1981; Levie & Lentz, 1982; Levin, Anglin & Carney, 1987; Levin & Lesgold, 1978).

- *Facilitate* reading, make it easier for poor readers to comprehend, learn, and recall things they read in a text (Duchastel, 1978).
- *Facilitate* retention (Dwyer, 1978; Winn, 1993).
- *Facilitate* understanding (Pettersson, 1989).
- *Flatter* the audience (Zakia, 1985).
- *Focus* attention (Clark & Lyons, 2004).
- *Focus* on a particular aspect (Wileman, 1993).
- *Foster* generalizations of responses to new situations (Dwyer, 1978).
- *Gain or get attention* (Duchastel, 1978; Duchastel & Waller, 1979; Evans, Watson and Willows, 1987; Gagné, 1977, Holliday, 1980; Keller & Burkman, 1993; Lentz, 1982; Lester, 1995; Levie & Levin, Anglin & Carney, 1987; Moriarty, 1991; Pettersson, 1993; Wileman, 1993).
- *Give* precise descriptions and information (Zimmer & Zimmer, 1978).
- *Glorify* an individual or a group (Dondis, 1973).
- *Guide* learners to think carefully and make conclusions (Dwyer, 1978; Santas & Eaker, 2009).
- *Help* learners remember what they read (Levie & Lentz, 1982).
- *Help* learners understand what they read (Levie & Lentz, 1982).
- *Help* people remember (Wileman, 1993).
- *Hold* attention (Levin, Anglin & Carney, 1987).

- *Identify* something (Dondis, 1973; Dwyer, 1972; Heinich, Molenda & Russell, 1982).
- *Illustrate* a principle (Clark & Lyons, 2004).
- *Illustrate* a theory (Clark & Lyons, 2004).
- *Illustrate* appearance (Pettersson, 1989).
- *Illustrate* cause-and-effect relationships (Clark & Lyons, 2004).
- *Illustrate* key points and relationships (Massoumian, 1989).
- *Illustrate* oral and printed communication (Dwyer, 1978).
- *Illustrate* selected main points (Fredette, 1994).
- *Illustrate* something (Melin, 1986a).
- *Impact* emotions (Vernon, 1953).
- *Increase* learner interest, motivation, curiosity, and concentration (Dwyer, 1978).
- *Increase* learning retention (Wileman, 1993).
- *Increase* reliability of communication (Dwyer, 1978).
- *Induce* perspective into a text (Peeck & Goud, 1985).
- *Influence* viewers (Lester, 1995).
- *Inform*, as a main information source (Fredette, 1994).
- *Instruct* (Levie & Lentz, 1982; Pettersson, 1989).
- *Integrate* facts, skills, and judgements (Dwyer, 1978).
- *Interpret* and explain difficult phenomena (Elkins, 2010; Levin, Anglin & Carney, 1987; Winn, 1993).
- *Introduce* new information (Dwyer, 1978; Griffin, 1994).
- *Isolate* specific instructional characteristics (Dwyer, 1978).
- *Label* facts (Levie & Lentz, 1982).
- *Learn* (Dwyer, 1978; Elkins, 2010; Heinich, Molenda & Russell, 1982).
- *Link* information, and maintain the continuity of a presentation (Griffin, 1994).

- *Maintain* attention (Peters, 1978).
- *Maintain* interest by presenting a mesmerizing image or sequence (Moriarty, 1991).
- *Maintain* learner attention (Keller & Burkman, 1993).
- *Maintain* the continuity of a presentation (Griffin, 1994).
- *Make* learning more precise and complete (Dwyer, 1978).
- *Make* reading more concrete (Duchastel, 1978; Travers and Alvarado, 1970).
- *Make* reading more enjoyable (Duchastel & Waller, 1979).
- *Memorialize* an individual or a group (Dondis, 1973).
- *Memorize* facts (Heinich, Molenda & Russell, 1982).
- *Minimize* cognitive load (Clark & Lyons, 2004).
- *Modify* behaviour (Lester, 1995).
- *Motivate* a person to pick up, browse through, and read a text (Duchastel, 1978, 1983).
- *Motivate* students (Evans, Watson and Willows, 1987; Fredette, 1994; Heinich, Molenda & Russell, 1982; Winn, 1993).
- *Name* content (Brumberger, 2011).
- *Organize* information, temporal and spatial relationships (Clark & Lyons, 2004; Levin, Anglin & Carney, 1987).
- *Organize* new information (Dwyer, 1978).
- *Overcome* time and distance (Dwyer, 1978; Moriarty, 1991).
- *Perceive* objects (Elkins, 2010).
- *Perpetuate* ideas that words alone cannot (Lester, 1995).
- *Persuade* ideas that words alone cannot (Lester, 1995).
- *Persuade* people to buy a particular product or think a specific way (Lester, 1995).
- *Persuade* someone (Heinich, Molenda & Russell, 1982; Lester, 1995).
- *Persuade* the audience (O'Keefe, 1990; Zakia, 1985).

- *Present* a variety of vantage points, locations of parts, relationships (Dwyer, 1978).
- *Present* abstract and difficult material (Levin, Anglin & Carney, 1987).
- *Present* more information than text in a given amount of space (Wileman, 1993).
- *Present* new information (Dwyer, 1978).
- *Present* outlines, lists, and complex materials (Massoumian, 1989).
- *Preserve* people, places, and objects (Dondis, 1973).
- *Prevent* misconceptions (Fredette, 1994).
- *Provide* additional clarifying information, metalinguistic function, (Peters, 1978).
- *Provide* authority, information, overview, and variation (Pettersson, 1989).
- *Provide* background information (Fredette, 1994).
- *Provide* extra linguistic information (Levie & Lentz, 1982).
- *Provide* greater flexibility and variety in the organization of instruction (Dwyer, 1978).
- *Provide* instructional feedback (Dwyer, 1978).
- *Provide* organization and a framework for a text (Levin, Anglin & Carney, 1987).
- *Provide* retrieval cues for factual information, a *mnemonic* function (Clark & Lyons, 2004).
- *Raise* questions (Dwyer, 1978).
- *Receive* a represented message, conative function (Peters, 1978).
- *Recognize* objects (Brumberger, 2011).
- *Record* people, places, and objects (Dondis, 1973).
- *Reinforce* aural and printed instruction (Dwyer, 1978).

- *Reinforce* memory (Gilbert, 2005; Winn, 1993).
- *Reinforce* oral and printed communication (Dwyer, 1978).
- *Reinforce* the creative concept (Moriarty, 1991).
- *Reinforce* the text (Hunter, Crismore & Pearson, 1987).
- *Replicate* people, places, and objects (Dondis, 1973).
- *Represent* instructional content (Clark & Lyons, 2004; Levin, Anglin & Carney, 1987; Winn, 1993).
- *Respond* to need (Dondis, 1973).
- *Scare* the audience (Zakia, 1985).
- *Seduce* the audience (Zakia, 1985).
- *Serve* as advance organizers of information (Wileman, 1993)
- *Shame* the audience (Zakia, 1985).
- *Sharpen* powers of observation (Dwyer, 1978).
- *Show* changes in objects over space (Clark & Lyons, 2004).
- *Show* changes in objects over time (Clark & Lyons, 2004).
- *Show* qualitative relationships among content (Clark & Lyons, 2004).
- *Show* quantitative relationships among two or more variables (Clark & Lyons, 2004).
- *Show* spatial relationships (Zimmer & Zimmer, 1978).
- *Show* steps in a process (Levin, Anglin & Carney, 1987).
- *Show* time and magnitude relationships (Pettersson, 1989).
- *Simplify* complex concepts (Wileman, 1993).
- *Solve* problems (Fredette, 1994).
- *Span* linguistic barriers (Dwyer, 1978).
- *Stimulate* discussion (Dwyer, 1978).
- *Stimulate* incidental learning (Fredette, 1994).
- *Stimulate* interest (Keller & Burkman, 1993).
- *Substitute* words (Levie & Lentz, 1982).

- *Sum* up information for retention and recall (Massoumian, 1989).
- *Summarize* important parts of a text (Hunter, Crismore & Pearson, 1987).
- *Summarize* the important points in a lesson (Dwyer, 1978).
- *Supplement* verbal information through elaboration (Fredette, 1994).
- *Support* attention (Clark & Lyons, 2004).
- *Support* motivation (Clark & Lyons, 2004).
- *Support* statements made by linking visuals in a presentation (Griffin, 1994).
- *Support* transfer of learning (Clark & Lyons, 2004).
- *Sustain* statements made by linking visuals in a presentation (Griffin, 1994).
- *Tease* the audience (Zakia, 1985).
- *Thinking critically* (McKenzie, 2008)
- *Transfer* culture to immigrants when employed in teaching aids (Aronsson, 1983).
- *Transform* content (Levin, Anglin & Carney, 1987).
- *Understand* content (Brumberger, 2011; Elkins, 2010; Mathewson, 1999).
- *Verify* research (Fredette, 1994).
- *Visualize* instruction (Dwyer, 1978).
- *Wrap up* information in a presentation (Griffin, 1994).

The above list contains more than 200 opinions about image functions. More than one hundred different explanatory verbs are used to express these opinions. According to researchers in the areas of instructional message design, visual literacy, and visual communication the most common opinions on functions

of visuals concern attention: *attract, gain, get, hold and maintain attention*. Other common explanatory verbs are: *facilitate, provide, persuade, create* (an interest in), *illustrate, clarify, motivate, present,* and *reinforce* information (to someone). Most of these purposes can be looked upon as clearly pedagogical or cognitive, in contrast to pictures used for entertainment, decoration, advertising or marketing.

In addition to purely realistic visuals, there are also visuals that can be described as "metaphoric." They exemplify and depict some linguistic metaphor. Visuals of this kind are not symbolic in any semiotic (Jacobson, 1976) or art science sense (Berefelt, 1976). Melin (1986b) noted that metaphoric pictures are particularly abstract and therefore intellectually demanding. In various ways, pictures often have important social functions in the home, at school, in organizations, and in society.

Picture creation is more important than the visual results in certain instances. Some pictures may not have any or only a limited function once created. Modern cameras that automatically set the exposure, focus the lens, and advance the film have made it possible for almost anyone to take pictures. More than 90% of all Swedish families own at least one camera. Two thirds of the population make a movie or take still photographs at some time during any year. Millions of amateur photographs are the result. The advent of lightweight, portable VCR equipment has opened up new horizons for non-professional creators of moving pictures.

Moving pictures

Moving pictures can be affective and provide readers with entertainment and reinforce an experience both positively and negatively. They can trigger associations and influence emotions and attitudes, especially in movies and TV (Zakia, 1985). In advertising and television, pictures may carry subliminal messages. Ads for liquor or cigarettes, for example, sometimes use sexual symbols (Zakia, 1985). Leshin, Pollock, and Reigeluth (1992) noted the attention-getting capability of several visual devices. They mentioned zoom lens movement to emphasize important details. Other devices are split screens, shading and contrast, voice-over narration, text, and graphics. Leshin et al. (op. cit.) suggested that visual images may facilitate comprehension and retention of information through organizational, structural, and mnemonic (assisting memory) functions.

Rowntree (1990) identified motion as a valuable characteristic of video. The author suggested the following video applications in which movement is an important attribute:

- To demonstrate the operation of tools or equipment.
- To demonstrate skills that learners are expected to emulate.
- To conduct experiments in which the processes must be observed.
- To present a dramatic or musical performance in which it is necessary for learners to see as well as hear the performers.
- To analyze change over time using animation, slow motion, or time lapse photography.
- To reveal the spatial, three-dimensional qualities of an object or structure.

- To transport learners into situations that could not otherwise be experienced
- To present primary source material for analysis, such as archival film of historical events or videotapes of naturally occurring situations.

The contents of movies and television programmes are presented in a preordained fashion, decided on by the producer. This preordained fashion tends to encourage passivity in the viewers and to perform at a low cognitive level. The same is true of prepared oral presentations, like formal speeches and rigid lectures. However, the reader of a book or a newspaper digests the textual and the pictorial information at his or her own pace. Interested readers are active and perform at a higher cognitive level. Readers that are not interested in the subject matter may easily become passive.

Interactive video programmes and multi-media presentations make it possible to combine sound and moving pictures in various ways. Thus, these media can arouse considerable activity, enjoyment and commitment in the user. Because an interactive video programme and a multi-media presentation can stimulate the user to perform at a higher cognitive level, it has the potential to function well, both as a conveyor of information and as a teaching aid.

Interpretation of intended image functions

In an attempt to study the intended functions or purposes of visuals, two inquiry studies were performed with students and teachers in Sweden. A total of 449 subjects took part in these studies, and mentioned a total of 827 image functions.

Presumed intentions of the senders

From 1986–1991, 180 students at Stockholm University were asked to make an attempt at evaluating the senders' presumed intention or intentions for visuals used in printed media (Pettersson, 1993). The 238 visuals collected for analysis and discussion in class were mainly published in newspapers, magazines, and brochures.

It was obvious that students saw visuals as performing a great number of different functions. Students mentioned no less than 63 different presumed functions. In many instances (51%), subjects felt that the sender's intention was to induce receivers to take a stand for some person or some issue. This obviously applied to visuals in advertising but also concerned visuals in editorial text to some extent. In this category the top ranking functions were: sell products, sell a life style, sell services, convey or create associations, and convince viewers about something.

In some instances (30%), subjects felt that the senders were attempting to convey objective information about something. Here the top ranking functions were: convey factual information, illustrate factual circumstances, document, and instruct.

In a few instances, (11%), subjects felt that the sender's intention was to induce receivers to take an active stand against some person or some issue, and in a few instances, subjects felt

that senders were attempting to provide entertainment (5%), or that visuals were used as adornment or decoration (3%). The functions arouse interest, create needs, document, sell, and supply information were not mentioned in the literature reviewed above.

Presumed purposes for using visuals in teaching

From 1990–1991, 82 other students at Stockholm University were asked to exemplify their teachers' "presumed purposes" for using visuals of different kinds in their teaching. The periods to be considered were their time at senior high school, and the previous semester at the university. The students had been to several different schools, studied different subject matters, and been taught by different teachers. From the students who took the same course during the previous semester one student was randomly selected to represent each group.

82 subjects answered the inquiry with a total of 391 presumed purposes (147 different). Some subjects provided one or two purposes. Other subjects gave more examples. Some of the purposes are fairly common, while other purposes are very specific. Several purposes are similar; some are synonyms or closely related to each other. Among the students' opinions about the teachers' presumed purposes with visuals we find some of the purposes mentioned in the literature quoted in the section Traditional Image Functions above, but also other purposes.

After grouping and ranking it is clear that the most outstanding purposes are to show (77), and to explain (44). Other common purposes are to visualize (25), illustrate (24), clarify (23), inform (21), summarize (21), convey (17), learn and re-

member (17), mediate (17), elucidate (16), present (15), and give perceptions (13). Less common purposes are instruct (11), describe (10), entertain (10), complete (9), facilitate reading (9), inspire (8), make concrete (8), document (6), exemplify (5), compare (5), and "other" (10). The functions complete, describe, document, elucidate, inspire, and mediate were not mentioned in the literature reviewed above.

Purposes for using visuals in teaching

In one assignment 40 teachers at junior high schools in Sweden revealed their purposes for which pictures were used in their classrooms in 1990. These teachers provided 84 different purposes. To a large extent we find these "teacher purposes" also in the material provided by the students. The teachers only mentioned cognitive and pedagogical uses. The most common purposes were to explain (20), show (19), and present (8). Several additional purposes were also mentioned. Some of these were not mentioned in the literature reviewed above: context (1), deepening (2), describe (1), describe circumstances (1), elucidate the evolution (1), give a background (1), give a break (1), give a perspective (2), inspire to writing stories (1), minimise abstractions (1), and one picture says more than a thousand words (4).

In one international study Pettersson et al. (1991) focused the interest on the teachers (the senders) and their actual use of media and pictures in their teaching of geography in secondary schools in five countries: Australia, Greece, Japan, Sweden, and the USA. Teachers were asked to answer questionnaires. One of the questions was: "What is the purpose of using pictures in the teaching of geography?" 101 teachers provided 110 purposes for

using pictures in the teaching of geography. There were no less than 66 different purposes. Results from this study confirmed the above studies. Visuals are used for many different and individual purposes. The most commonly cited purposes were: for factual realization to get realistic understanding and knowledge (13), to attract interest of subjects (9), and to make images of the area (9). This study showed that there are clearly different teaching "styles" in different cultures. There seem also to be different "fashions" in teaching practice that differ from culture to culture and can change over time within different cultures. Fashion in the use of educational media is partly related to the technology that is available in that specific culture at that time.

Purposes for using visuals in information materials

In a fifth inquiry (1998) Information Design students at Mälardalen University in Eskilstuna were asked to provide one to five examples of the purposes for using visuals in information materials in printed media. 46 subjects answered the inquiry with a total of 179 purposes (83 different). Some of the purposes are fairly common, while other purposes are very specific. Several purposes are the same. Some purposes are synonyms or closely related to each other.

Among the students' opinions about the purposes with visuals in information materials we find most of the purposes mentioned in the literature quoted in the section Traditional Image Functions above, but also other, "new" purposes. After grouping and ranking it is clear that the most outstanding purposes are to visualize (33), clarify (28), inform (22), attract attention (20), facilitate reading (19), explain (17), and convey information (9).

Image functions in information design

There is often a clear difference between the intended and the perceived message (Pettersson, 1985). One way to decrease this gap is to supply all pictures with interesting and explaining captions, supporting the intended interpretations (Melin & Pettersson, 1991). When too many pictures of different types are used in one single message, some of the pictures may be ignored. There will also be less space for the text.

Unfortunately, often archival pictures are used in a way not intended. Sometimes the same pictures appear in several different contexts, which may confuse the readers. Some illustrations in contemporary textbooks appear to serve no useful purpose at all. Some picture editors admit that some of the pictures they put into textbooks are only there to "stimulate" the reader, to have "a life of their own," or merely to provide a "breathing space" within the text. Such uses seem very dubious. In fact, some publishers admit that the two main reasons to use pictures in their books are to 1) attract buyers, and 2) increase the prices.

Interviews with editors, art directors, and designers from major Swedish publishing houses showed that they, in the selection of visuals for reference books and textbooks, often ask themselves questions such as the following (Pettersson 1989, p. 145):

- Does the picture depict the right thing?
- Is the presentation of the subject satisfactory?
- Is the picture technically acceptable?
- Is the picture aesthetically satisfactory?

- Is the picture "flexible," i.e., will it work with different formats?
- Will the picture fit into a given area?
- Will the picture fit in with the other pictures on the same page?

In practice, many editors, art directors, and designers find that 1) procurement time, 2) availability, and 3) image clarity are the most important considerations in making their subjective choices among possible visuals. Evans, Watson and Willows (1987) interviewed editors, art directors, and designers from nine major Canadian publishing houses. They concluded (p. 90):

> Our interviews confirm Dwyer's (1972) summary that the selection and inclusion of illustrations in textbooks appear to be based on "subjective feelings of the designer about what is best, the accessibility of raw information, the availability of materials, the cost, the attractiveness of the finished product, and the availability of a ready market" (p. 16).

Marsh (1983, p. 101) provided the following eight guidelines for selecting a visual channel for a message:

- When messages are complex.
- When refer ability is important.
- When messages are long.
- When environment is noisy.
- When arrangement is complicated.
- When precise spatial discrimination is important.
- When simultaneous presentation is desired.
- When more dimensions are required.

Preference for a particular visual format does not necessarily result in increased learning. Yet, in the absence of more substantial data, information based on student preference has a meaningful role to play in affecting learning from information materials and instructional texts. All other things being equal, we should provide formats that are preferred by the viewer, thus making the text more attractive, and hopefully more motivating. Thus selection of artistic style for visual materials should not be an arbitrary decision, but always a conscious one. Although full-colour photographs increase the costs of trade books Ramsey (1989) suggested that publishers should increase the number of such books available for primary audiences. Today, however, there are only few informational books for children which meat these criteria. It is actually quite common that various kinds of abstract illustrations are used in textbooks.

In my view, visuals for information should be attractive but "unambiguous," i.e. not too "artistic" and therefore ambiguous. Visuals that are attractive and that people like also have greater impact. To increase interest in a material, it might be a good idea to use a blend of several kinds of visual types such as diagrams, drawings, and photos. Generally speaking it is not possible to rank the different types of visuals. Often the type of visual that should be used must be determined in each individual case with a view to various demands on the picture and the prevailing budget framework. It is often easier to control the production of a drawing than the production of a photograph. So a drawing may be the only realistic alternative in many situations. However, since pictures illustrated in more abstract styles, such as cartoon and expressionistic, might generate more

imagination such pictures might be used as stimuli for creative writing assignments.

It is not enough to select good visuals and make sure that all the pictures have relevant captions. To really help the readers to improve their use of visuals in textbooks, AV-material, and other teaching aids, we should give the teachers careful guidance, for instance in a teachers guide. The guide should:

- Show the purpose of each individual picture.
- Complete the caption and tell what each picture shows.
- Give different examples of how every picture can be used in the education, what is important to discuss, which tasks can be assigned in connection with the picture, and so on.
- If needed provide complementary facts. For instance, explain how the picture has been produced.
- Account for name of photographer, artist or other picture creator.

Effective visuals for information should create an experience for the reader. The reader must:

- See or rather "discover" the picture.
- Pay attention to the picture.
- Read the picture in an active and selective way.
- Process the information mentally.

Winn (1993) concluded that pictures play many roles in instruction. It is therefore necessary to know precisely what a picture's function is intended to be before it is designed. Cognitive and decorative functions should never be confused or mixed (Pettersson, 1989, 1993). At some point, illustrations move from being engaging motivators to engaging distracters (Evans, Wat-

son and Willows, 1987). When too many pictures are used, readers may ignore many of them. Massoumian (1989, p. 19) noted, "Haphazard use of visuals may lead to minimal or no instructional gain and gradual loss of effectiveness as an instructional tool."

In information design it must be possible to understand the message and to be able to believe that the information is correct. A message with high credibility has a good structure, convincing arguments, proper references, and relevant examples. It is a major advantage if text and pictures have good legibility as well as good readability. In my view, a picture used in information materials should depict reality in a manner appropriate to the content and be as relevant and credible as possible. However, many pictures in textbooks and newspapers have been edited in order to change their importance and impact. Pictures can easily be enlarged or reduced in size, which will influence readability. It is often very easy to crop the original picture.

However, cropping is not merely an aid to art or to journalism; it may also be a tool for unscrupulous editors. Many photographs lend themselves to manipulation of the representation. They are susceptible to different crops to support different meanings and various ideas. It is also possible to expand the original picture. Parts of the picture can be deleted, added, altered, moved or changed in shape. A colour can be changed, removed or added. This practice of editing is often unlawful.

Visuals cost money, often quite a lot of money. But in many situations a "good" picture need not cost more than a "bad" picture! Spending a lot of time on the visualization process and on sketches (usually a less expensive process than the cost of origi-

nals, “masters,” and printing runs) may therefore be worthwhile.

It may be concluded that one important function of visuals may be to aid credibility to the sender or the source. Thus designers of information and instructional messages should design and select visuals with great care.

Image functions in teaching and learning

Pictures and images are often used in teaching and learning, and in information materials. It is obvious that visuals may have, and often have many different functions. As noted above the most common opinions presented by researchers in the areas of instructional message design, visual literacy, and visual communication on functions of visuals concern *attention*. Several researchers mentioned explanatory verbs like attract, gain, get, hold and maintain (attention). Other common explanatory verbs are: facilitate, persuade, provide, create (an interest in), illustrate, clarify, motivate, present information (to someone), and reinforce. This “researcher list” differs from the opinions provided by the teachers and the students.

According to Fredette (1994, p. 243) a 1978 survey of 72 sixth through ninth grade teachers in Australia revealed the purposes for which photographs were used in their classrooms. The main reasons were for display only, to add decoration, to illustrate selected main points, for motivation, and to stimulate incidental learning. According to the body of research cited in the first section of this paper the main functions of still pictures are to: attract, gain, get, hold and maintain attention, to facilitate, persuade, provide, create (an interest in), illustrate, clarify, motivate, present, and reinforce. The inquiries with students

and teachers presented in the previous section showed that there might be many purposes for the use of visuals in printed media.

Most of the purposes can be looked upon as clearly pedagogical or cognitive, in contrast to pictures used for entertainment, decoration, advertising or marketing. According to students the most common purposes of pictures in the school environment were to: show, explain, visualize, illustrate, clarify, inform, summarize, convey, mediate, elucidate, present, give, instruct and describe. The teachers noted: explain, show, factual realization, attracts interest, present, and make images.

Evans, Watson and Willows (1987) noted that the attention-getting and motivational aspects of illustrations in textbooks seemed to predominate among the teachers in Canada. This was however, not the case among the teachers in the sample from Sweden. The Canadian teachers made very few direct references to illustrations in the classroom, and they provided little guidance in the educational functions that illustrations are thought to serve. Gustafsson (1980a, 1980b) found that this also was the case in Sweden.

Experiments with pupils in junior schools (Eklund, 1990), in intermediate schools and in junior high schools (Backman, Berg & Sigurdson, 1988) showed that pupils in Sweden had a very low "pictorial capability." At all levels pupils have large difficulties in interpreting, as well as in expressing picture content. Low "pictorial capability" is largely true also for the teachers, who very often lack both education and training in visual language and in visual communication. This is quite remarkable since the curricula in Sweden both assume and require all

teachers to be responsible for teaching about visuals as a means of communication.

I agree with Larsson (1991) who wrote (p. 105, in translation): "... it is important that all persons involved increase their knowledge of pictures and the function of pictures in textbooks: teachers, pupils, publishers, authors, designers, artists." Gayer (1992) stated that different types of visuals can be of great use in education. She certified that it is a serious deficiency that many teachers have insufficient knowledge of how visuals function. As previously noted we know that pictures can have a positive, a neutral, or a negative effect on learning (Evans, Watson & Willows, 1987; Furnham & Williams, 1987; Gunter, 1980; Levie & Lentz, 1982; Levin et al., 1987; Massoumian, 1989; Melin, 1999b; Pettersson, 1989, 1993; Rieber, 1994; Sims-Knight, 1992; Sung-Hee & Boling, 2010; Winn, 1993).

Vogel, Dickson, and Lehman (1986) showed that it is undeniable that visual presentation support is persuasive. Presentations using visual aids were 43% more persuasive than unaided presentations. At the same time, research in the area of reading indicates that the type of visuals that are used is an important variable in reading comprehension. However, regardless of the intended functions pictures are not always used in an active way at school (Pettersson, 1990). On the contrary, pictures in textbooks are often ignored and "skipped" (Lindström, 1990). Most students do not attend to the visuals unless they are instructed to do so (Pettersson, 1990; Reinking, 1986).

Hannus (1996) used eye-movement equipment and studied how pupils picked up information while learning from textbooks. He concluded that the learning effects of textbook illustrations are slight because not enough attention is paid to the

illustrations in the books. Thus the learning functions of illustrations were less than expected.

In some textbooks, the purpose of many pictures seems to be purely decorative or entertaining and not at all cognitive. If a textbook has many pictures that only are decorative and entertaining, it may well contribute to “image overload” and cognitive pictures being skipped. This may be one reason for textbook pictures not being used effectively. In such cases, pictures may actually decrease the quality of the textbook, and only raise its price. It is possible that certain types of illustrations, incorporated to “stimulate” the reader’s imagination and interest, could instead have a heavily governing effect that stifles the imagination and diverts interest from the information the author wishes to convey.

As seen from the opinions presented by the teachers, visuals that are used in teaching may have many different purposes. This raises quite high demands upon teachers as well as pupils and students and strengthens any requirements for education and training in visual communications. The reader should always be encouraged to find out what the senders’ intentions are. Why is the picture there? What is the function of the picture? What is the main message? Which are the secondary meanings? Which associations does the picture raise?

Image functions–conclusions

As seen from the sections above visuals may have many functions in communication. More than one hundred different explanatory verbs are used to express these opinions. According to researchers in the areas of instructional message design, visual literacy, and visual communication the most common opinions

on functions of visuals concern attention. The words attract, gain, get, hold and maintain attention are mentioned by the researchers. Other common explanatory verbs are: facilitate, provide, persuade, create (an interest in), illustrate, clarify, motivate, present, and reinforce information (to someone).

The inquiries with students and teachers also showed that there may be many purposes for the use of visuals in printed media. Most of the purposes can be looked upon as clearly pedagogical or cognitive, in contrast to pictures used for entertainment, decoration, advertising or marketing. The most common purposes of pictures in the school environment were to: show, explain, visualize, illustrate, clarify, inform, summarize, convey, mediate, elucidate, present, and give (perceptions), instruct, describe, and entertain. There seem to be different "fashions" in teaching practice that differ from culture to culture and can change over time within different cultures. Fashion in the use of educational media is partly related to the technology that is available in that specific culture at that time.

The most common purposes of pictures in information design are to visualize, clarify, inform, attract attention, facilitate reading, explain, and convey information. The type of visual to be used in the production of materials for information and learning must often be determined in each case with a view to specific demands on the visual, and also to the prevailing budget framework.

Pictures and the "total teaching aid"

The development of compact discs and the Internet opened opportunities to producers of teaching aids. It is possible to create "the total teaching aid" encompassing text, sound, pictures, numerical information, and opportunities for various kinds of information processing in a single medium. A "total teaching aid" is a multimedia database offering the user complete freedom in moving back and forth between verbal, numerical, visual, and audio information. This enables people with all kinds of modalities, i.e., verbal, visual, kinaesthetic, or mixed modalities, to actively seek and find information that is actively transformed into experience and knowledge. (See the section *Modalities* in the book *Cognition*.)

In supplying answers to assignments or writing reports, students will have easy access to the necessary background information. They will also be able to retrieve suitable examples, "quotes" from the individual databases, and incorporate them into their own presentations. Numerical information in tables, for example, can be processed and presented as bar charts, curves, or pie charts providing a better overview. A teaching aid could also contain different kinds of computer-based educational games and the like.

Every published photograph has been involved in a selection process, not just once but repeatedly. First of all, the picture creator (photographer or artist) makes an extremely narrow selection from all the pictures that could be created on any given occasion. The picture editor then makes a selection from numerous alternatives in a collection or archive. As far as drawn illustrations are concerned, a number of alternative sketches often serve as the basis for discussions on the appearance of the

final originals. So a picture only depicts a selected slice of reality, one person, one object or one event, for example, always surrounded by un-depicted things and circumstances occurring before and after each selected picture. Most graphic products can only display a rather limited number of pictures depicting a situation. However, an optical/electronic system is capable of storing an extremely large number of pictures, which need not be cropped as severely as "print published" pictures. So the user has a greater opportunity to utilize picture information as a "resource," "information bank," and retrieve information that is relevant and of interest on any given occasion.

A stored image is much larger than the image displayed on the screen (illustration above). Only the central part is displayed. The entire picture can be viewed by scrolling the screen image up or down or to the side. Horizontal and vertical rulers with cursors outline the position of each displayed image window. Here, electronic media are completely superior to all traditional media.

For economic reasons, a book cannot usually contain multiple versions of a picture cropped in different ways. The sender's perception of what is important is the deciding factor in the choice of the picture selected for publication. With use of the "total teaching aid" the user of the system, the learner, can decide what is important to her or to him.

The stored image can be scaled and shrunk to a fraction of its normal size so the entire image fits on the terminal screen. We can zoom in on any detail displayed on the screen by enlarging that part of the image, thereby changing the scale. The result is like viewing part of the picture through a magnifying glass. If sufficient computer and storage capacity is available, step-less

enlargement or fixed, multiple degrees of magnification could be allowed. Image magnification or shrinkage does not change image contents but it can have a major impact on image perception.

Possibilities for enlargement are already available in several computer systems. In the future this will probably be standard and with better and better performances. How can an image be processed? Modern, computer-based systems for processing graphical images offer wide-ranging opportunities for simple editing and manipulation of image contents. In addition to changing scale, as previously mentioned, the user can change projection, crop or expand, reduce, delete, modify, move, turn, supplement, isolate or combine various image elements. Pictures can be stored as object oriented descriptions, in bit-mapped form or as a combination of it. Image processing with computers offers incredible opportunities. However, copyright laws and ethical rules make free use of these opportunities impossible. Manipulation or counterfeiting of image contents are condemned. In commercial situations the contents of a picture may not be changed without the expressed consent of the picture's copyright holder.

What happened before and after the displayed picture? Picture sequences depicting various events can be stored instead of individual pictures. Animation, with the option of freezing each component image, could be used. By the use of advanced computerized image compression it is also be possible to show live sequences.

Among traditional media this technique is used with great success in comic strips. Comics are usually examples of presentations where text and pictures are highly integrated. Producers

of teaching aids and producers of encyclopaedias may learn a lot from the creation of comic strips. Experiences from the use of overhead transparencies may by used to guide production of several overlays. Pointing at different image elements opens one or more windows to other databases with information on picture contents. This information may comprise explanatory text or additional pictures. Pointing at a word in the text opens new windows containing even more detailed information etc. Sound can be used in some contexts. In an "electronic dictionary," for example, spoken words are displayed on the screen. Thus learning is enhanced. Music and sound effects can also be used.

Use of the windowing technique and electronic "clippings" makes it easy to combine images and text or parts of texts in the creation of new documents. The displayed picture is a basic picture. It can be stored with several different overlays containing supplementary information in the form of various symbols, such as terms in different languages. This gives us an opportunity to adapt and structure information by rising above the picture plane. The user can also descend below the picture plane.

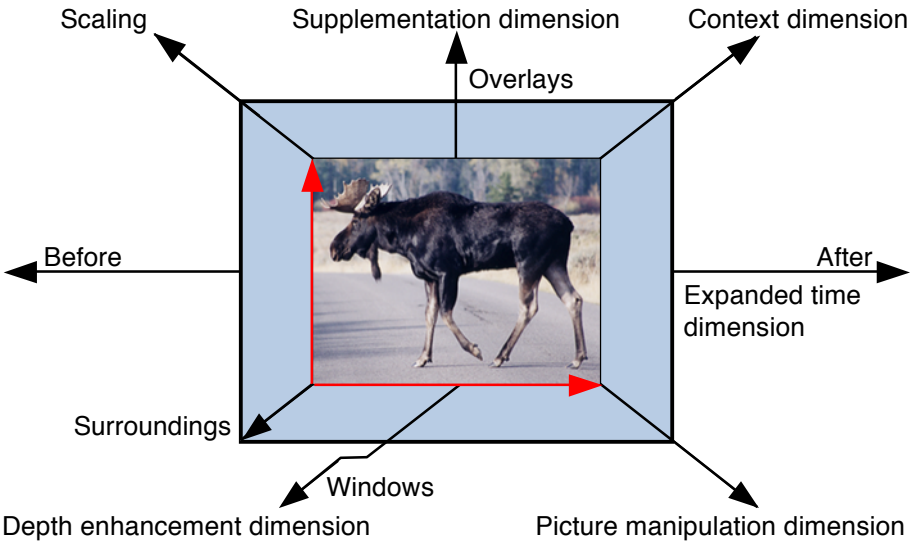
Kollerbaur (1983) developed an approach where the computer is an aid or tool for learning. This approach is based on cognitive theories for learning, focusing on the learner and the learning problem rather than on the technology as such. It was concluded that:

- The learner should be active and creative.
- The interactive system should be used to solve problems and improve learning.

- Programs should provide access to the special qualities of the computer as a means for handling and presenting information.
- The system should only be used when existing methods and other aids are insufficient.
- Users (teachers and students) should be able to influence the systems, which consequently have to be flexible.
- The systems should be easy to learn and use.

Most of the options discussed exist in various systems. Developments are very rapid. New products and new systems are released all the time. We can be sure that "databases of the future" will offer completely new options of very considerable theoretical and practical interest. The "total teaching aid" and the "total encyclopaedia" employ some of the best qualities of the existing media. Furthermore new qualities are added.

As our previous examples showed, new dimensions can be added to pictures stored in a database. We can attain an expanded time dimension by "before-now-after" picture storage. Or we can expand to a movement dimension by the use of animation. Not cropping too severely and retaining elements around the main subject attain a context dimension. A picture manipulation dimension occurs when we enlarge, shrink, change projection, crop or expand, delete, change, move, turn, supplement, isolate or combine different image elements in new ways. Departure from the picture plane and utilization of overlays provide us with a supplementation dimension. We can attain a depth-enhancement dimension by employing windows opening on other databases.



Databases offer new options for handling pictures. Now pictures get new dimensions and several new opportunities.

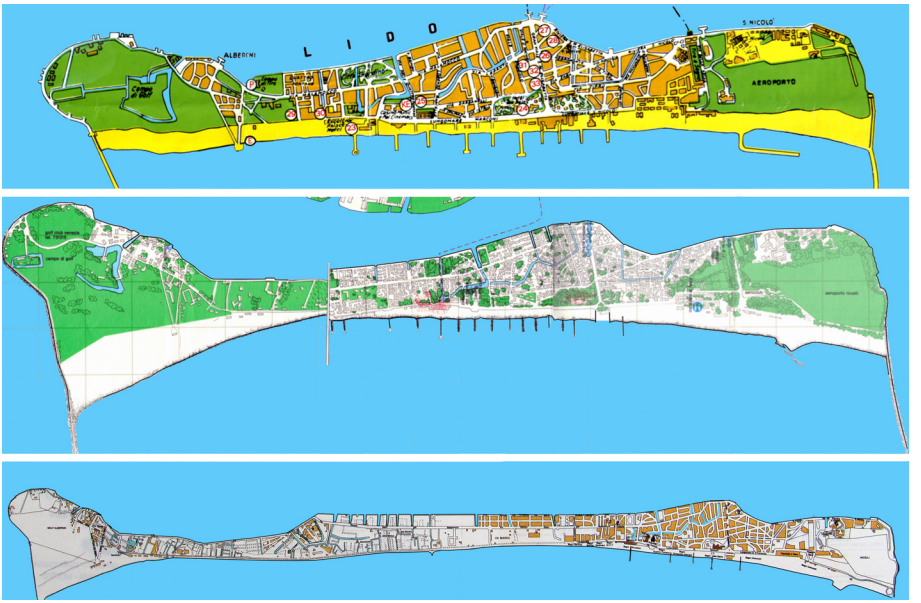
Visual content

In the design and production of visual information, we have to consider the characteristics of visual languages. We need to know how the illustrations will be used. We should consider image variables related to content, graphic execution, context, and format.

Before starting to design visual information, it is very important to define *how* the illustrations can be used. We need to decide if we will use photographs or artwork. The most important factors seem to be informational and learning objectives and user characteristics. Visuals may not always be really necessary but are useful in many situations. However, in some situations, all kinds of pictures may be distracting. In these cases visuals should not be used.

In the design and production of visuals for instruction or for education, pictures must contain the information they are intended to convey. The visuals must be relevant to the situation. Without clear content, the visual will not be able to function well.

We should carefully define the objective of each visual. What information or knowledge is the visual intended to convey? Who is the sender? Who are the receivers? And in which medium or media is the visual to be distributed? Cues for understanding the message in a visual are different in various cultures as well as in different socioeconomic groups. It is very important to consider these factors in each specific situation.



The island Lido is located South-East of Venice, Italy. Lido is a long and narrow island. The island is indeed presented very differently in these three maps. As well as other pictures, maps must obviously contain the data and the information that they are intended to convey to the intended audience. Here the maps are very much reduced in size.

Structure

A well-defined structure of content facilitates learning. There is a need for structure in complete material as well as within parts of the material. Normally the structure of an instructional message is built to be continuous, to form a connected whole that presents the message clearly to learners. The instruction progresses logically, step by step. After an initial orientation or instruction, instructional materials should develop at a pace that is suitable for the intended audience.

When the learner doesn't see, read, or hear what she or he expects to see, or can't find agreement between verbal and visual content, the message is likely to be misunderstood. Since the competition for our attention is very fierce in commercial arts and in advertising, discontinuity is often used intentionally to attract and even to hold attention. The intended message may be hidden within verbal or visual puns, metaphors, satires, parodies, or humour. In these cases, designers break the traditional rules of instructional design. It might also be possible to use the unexpected to attract attention to instructional material as well.

Degree of realism

A visual should usually possess a moderate and selected degree of realism and be true-to-life. Rather often this means culturally accurate detailed drawings in natural colour. However, to a large extent realism is determined by conventions. What is seen as realistic in one culture may be seen as incomprehensible in another culture. Brouwer (1995) noted that realism is determined by the extent in which people consider something abstract or concrete. Within a specific culture recognition of fa-

miliar objects is remarkably high. But some objects, for example, a fire or a river, are not readily described in line drawings.

According to Zimmer and Zimmer (1978), Cook (1980) and Brouwer (1995) six factors determine the realism of an image. These factors are: colour, form, motion, perspective, recognizable details, and scale. Illiterate people in rural communities in Africa have problems with understanding the visual conventions generally applied to these factors.

A photograph, which is clear in Western eyes, can cause serious problems for a visually poorly trained person. A photograph of a tree means an enormous change in scale. Understanding of pictographic images and graphic symbols requires a considerable set of conventions to be understood. Western viewers have learned to separate the important stimuli from background noise in pictures. This is, however, not at all the case with illiterate people. A woman wearing different clothes, with a different hairstyle from people in the rural neighbourhood is not "one of us" and her problem or her solution to a problem is therefore irrelevant.

Just as the use of too many details, the use of too many colours in a picture may cause problems. Colour is strongly associative and it draws attention. This can be either good or bad. A "strange" colour may draw attention away from the important content in the picture. Colours tend to either persuade or scare off people. Because conventions differ from culture to culture, associations with a colour will differ as well. This became painfully clear with the use of light blue packages of contraceptive pills in certain parts of India, where this colour had the negative connotation of constipation (Epskamp, 1981, p. 29). It is not possible to depict movement well in pictures for illiterate people

in rural communities. Western conventions like “speed lines” need to be taught. Otherwise they are not understood.

Cartoons, line drawings, and photographs represent a continuum of realism.

The concept of perspective is not understood (Brouwer, 1995; Zimmer & Zimmer, 1978) in some cultures in Africa. By drawing in perspective it can happen that some objects are partly hidden behind other objects. Then people with little or no pictorial experience often have difficulties in understanding these kinds of pictures. The visual part of the object is being interpreted as the whole object, or the object in the foreground and the object behind it are seen as belonging together. Illiterates see a human head or hand without the rest of the body as bloody, or just funny. Informative pictures should be “unambiguous,” i.e., not too “artistic” and therefore ambiguous. Cartoons, line drawings, and photographs represent a continuum of realism in visuals.

Too little or too much realism in a visual can interfere with the communication and learning processes. Learning is always related to the needs of the learners and to the level of objectives in each specific situation. Low-level objectives, such as naming of objects, need only a limited amount of information. High-

level objectives, such as synthesis and analysis, need a lot of information. Learners being exposed to “new” information may profit optimally from line drawings, whereas learners who are familiar with the content area may profit from more realistic types of illustrations.

Degree of detail

Zimmermann and Perkin (1982) noted that it is important to keep pictures as simple as possible. It is better to show a family planning clinic set against a plain background than against a city street. A crowded street will only detract from the message being conveyed. However, while excessive, unnecessary detail interferes with message understanding, comprehension may also be reduced by excessive deletion of detail.

A visual should contain the details that are essential in communicating the intended message. Too many details and too much complexity give rise to distracting “interference” and reduce the interest for the content and the impact of the important part of the content in the visual. Thus, we should avoid unnecessary elements in the picture. Too few details or too little complexity makes it impossible to understand the picture. For each picture there is an optimal degree of detail. This depends on the content, the format, the intended audience, and the objectives.

The amount of information and the degree of detail should be tailored to the medium and to the visual format. No more than a dozen major points can be effectively covered in a single pamphlet. A single page of a booklet should not include too many objects, nor should it attempt to portray more than one single step in a process. Each picture and each page should have

a single, sharp meaning. Multiple messages on one page will only confuse the receiver.

Slides, overhead transparencies and power point presentations often include far too much information, making them impossible for the listeners to read and comprehend in a short time. It is usually not possible to directly transfer printed images to slides or overhead transparencies. Pictures should be redesigned to best fit the medium. If necessary, use a series of visuals instead of only one visual, overloaded with information. In a slide show, "one-message slides" are usually ideal. This is also true for print material designed for children. A depiction of sequence in a series of frames should have a reasonable continuity. We are able to perceive up to about seven stimuli at the same time (Miller, 1956). It has been found that 7+/−2 is a reliable measure of human capacity.

A major factor in instructional effectiveness is *repetition*. Also, summaries will help learners to remember the most important points of the specific subject matter. Background colours, shades, frames, and special use of fonts and type size can be used to achieve unity.

Objects and events perceived as different or as similar in any way will be grouped and organized in our perception processes. Learning is facilitated when critical cues are apparent. Avoid non-critical cues if possible. In some cases a number of details in a picture or design may cumulate into larger coherent structures. Tufte (1990) noted that the *Vietnam Veterans Memorial* in Washington D.C. achieves its visual and emotional strength by means of a micro and macro design. From a distance the entire collection of names of 58,000 dead soldiers arrayed on the black granite yields a visual measure of what

58,000 means, as the letters of each name blur into a grey shape, cumulating to the final toll. When a viewer approaches, these shapes resolve into individual names. The same kind of micro and macro design is often used in the design of posters.

Factual content

In instructional message design, the content is very often factual. "Realistic" pictures can provide reasonably objective documentation of an object or a product.

Objects

The type of subject should be commonplace, easy to recognize, and neither uncommon nor abstract. The visuals should not contain any strange or unknown codes. Pictures are more likely to be successful if such things as facial features, clothing and buildings are based on what is familiar in that society. The more familiar a message is to its audience, the more readily it is perceived (Zimmermann & Perkin, 1982). Familiarity with the depicted objects themselves is basic to understanding. Also, the purpose of the visual should be obvious to the readers for whom the message is intended.

In developing countries, pictures of entire persons are most easily understood. Parts of the body like arms, hands, legs, and feet are more difficult to recognize. Even more difficult to recognize are tools and objects in the environment. People should, however, be dressed appropriately. Facial resemblance to members of the community is often an advantage. Zimmermann and Perkin (1982) pointed out that information material produced for national distribution might not be equally appropriate for all geographic areas.

Select a wide variety of examples as well as a variety of non-examples to enhance concept learning. In the examples the critical attributes should show as little variation and be as obvious and typical as possible. The non-critical attributes should show much variation and be as non-obvious and non-typical as possible. Objects and pictures of objects are better remembered than their names.

Time and place

A still picture is a "frozen moment in time." It does not show what happened before or what will happen after this specific moment. The passage of time is best illustrated with a series of illustrations that show details in the course of an event. However, illiterate people in developing countries may have difficulties in understanding that adjacent frames show the same people in a time sequence.

Picture context and picture composition can illustrate an age, a year, a season, and the time of day. Enhance comprehension with the aid of caption. Sometimes a time-scale may be useful. For AV productions it should be remembered that the perception of time durations and time intervals is relatively inaccurate without a standard or frame of reference. Time that is filled with activity appears to pass more rapidly than time that is not filled with any activity. Time is an essential factor in television and film. We can distinguish between objective time (clock time) and subjective time (perceived time). People seem to prefer programs with fast pace and action. Such programs also result in greater learning efficiency.

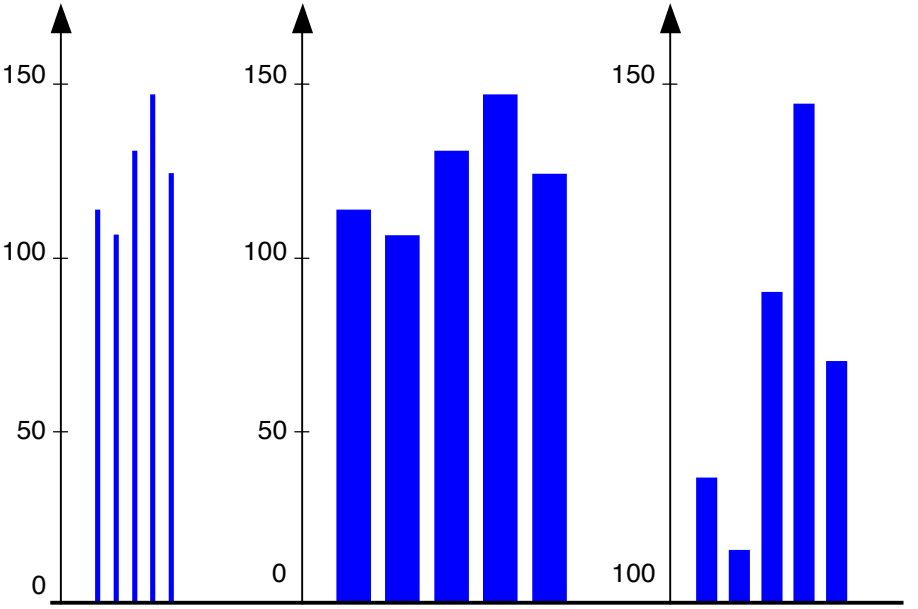
The location of objects may be very important, and may be shown in various kinds of scales, graphs, drawings, and maps.

(There is a large literature in cartography and the design of maps. However, these topics are not discussed in this chapter.)

Statistics

Numeric data are often used to illustrate situations such as relationships between variables and parts of a whole. Data can be presented in many formats. Graphical formats include comparisons of numbers, lengths, areas, volumes, positions, and also comparisons of different combinations of these variables. Discriminations are most readily perceived and learned when the differences between stimuli are maximal. If you wish to be clear, choose clear examples. Tufte (1983) wrote (p. 51): "Graphical excellence is that which gives the viewer the greatest number of ideas in the shortest time with the least ink in the smallest space."

Quantitative information should be made to stand out from the supporting information (like grids) by ensuring that the different items on a graph can be easily distinguished visually. People cannot compare sizes of areas or volumes readily or exactly. It is far easier to distinguish between lines than between areas or volumes. In most contexts, the difference in the sizes of circles, squares, triangles, ellipses, and several other two-dimensional geometrical shapes are underestimated. At the University of Athens research indicated that not all college students could accurately interpret data from a chart or a graph (Malamitsa, Kokkotas, & Kasoutas, 2008).



The three bar graphs in this illustration contain the same data, but they give us very different impressions. Bar graphs can easily mislead the viewers.

Distorting graphs by adding an artificial perspective or adding shadows will make it harder for readers to interpret the information in a correct way. It is easier to assess "parts of a whole" than "relationships between variables." When relationships between variables are to be presented, comparisons of lengths give the best results. When parts of a whole are to be presented, circle charts and pie charts may be used. However, don't use too many segments. The bars in a bar chart should be equidistant from one another, and the bars should be wider than the empty spaces between them. Design of individual

graphic elements is important. Patterns of bars should be discrete and not disturbing. Usually it is better to avoid mixtures of patterns and keep the bars as plain as possible. If stacked bar charts must be used, it is best to have dark tones at the bottom and successively lighter tones on top.

It is far too easy to convey misleading information and even des-information about statistical relationships by misuse of illustrations, and scales that are difficult to understand. We should use a scale break only when it is necessary. If a break cannot be avoided, the break must be very distinct and easy to understand.

Tufte (1983) provided guidelines for the "friendliness" of graphs. In friendly graphs, words are spelled out, they run from left to right (in western societies), and data are explained. Elaborately encoded shadings, cross-hatching, and colours are avoided. Friendly graphics attract viewers, colours are easy to distinguish, type is clear and precise, and is done in upper and lower case with serifs. In unfriendly graphs, abbreviations abound, words run vertically and in several other directions. These graphics are repellent and cryptic with obscure coding. The design is insensitive to colour-deficient viewers. Red and green are used for essential contrasts, and type is clotted and in all capitals in sans serif.

According to Tufte (1983), excellence in statistical graphics consists of complex ideas communicated with clarity, precision, and efficiency. Graphical displays should (p. 13):

- Show the data

- Induce the viewer to think about the substance rather than about methodology, graphic design, the technology of graphic production, or something else
- Present few numbers in a small space
- Make large data sets coherent
- Encourage the eye to compare different pieces of data
- Reveal the data at several levels of detail, from a broad overview to the fine structure
- Serve a reasonably clear purpose: description, exploration, tabulation, or decoration.
- Be closely integrated with the statistical and verbal descriptions of a data set.

Good designs are intriguing and curiosity provoking, drawing the viewer into the wonders of the data. Tufte (1983) noted that graphical competence demands three quite different skills (p. 87): the substantive, statistical, and artistic. Yet most graphical work today, particularly in news publications, is under the direction of but a single expertise–the artistic. Allowing artist-illustrators to control the design and content of statistical graphics is almost like allowing typographers to control the content, style, and editing of prose. Substantive and quantitative expertise must also participate in the design of data graphics, at least if statistical integrity and graphical sophistication are to be achieved. Tufte (1997, p. 48) argued that good design brings absolute attention to data.

Cifuentes, Myers and McIntosh (1998) noted that photo manipulation and stylistic embellishment may be used to create dishonest figures and tables. Both designers and readers must be mindful of possibilities for honesty and dishonesty in graphic

messages. However, by applying various methods of data analysis and representing data graphically, information designers can convey a message in different ways without jeopardizing the integrity of the message. For example, when using probability statistics, the information designer needs to carefully explain the appropriate interpretation of the representations that are used.

Events

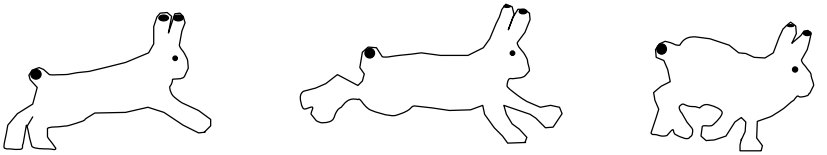
Several kinds of image content are related to events. Action, humor, drama, violence, time displacement, parallel action, metaphoric descriptions (symbolic actions), and change are all examples of events that may be the main content in visuals. It is known that pictures showing events usually are perceived more interesting and more effective instructional materials than static pictures. Obviously an activity is best shown in moving pictures.

Motion and rhythm

Several types of messages may benefit from being shown in media with moving pictures such as film, video and television. The best way to illustrate motion in a still picture is to depict a natural movement in a clear contrast to a static situation. In a still picture the impression of motion can be enhanced with graphical motion symbols such as speed lines that are common in comic strips. The meaning of these symbols has to be learned, and in fact are usually soon learned even by young children.

Animation is common in several media, like video and computer games. However, the movement is very powerful and attracts our attention. Thus other information may be totally

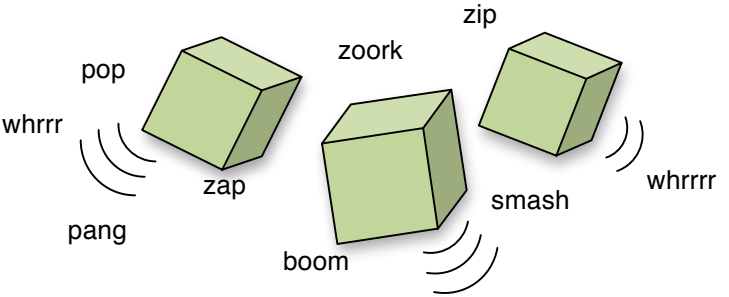
unseen and lost. The relation of figure to ground is particularly determinative of motion perception, which is highly related to our perception of depth. Perception of motion is influenced by contextual variables. In a still picture rhythm consists of regular changes between different levels of a variable. This can be illustrated by arraying image elements into distinct groups.



You can show movement with a series of still pictures. These pictures show how a hare moves.

Sound

The impression of sound in a still picture is most readily conveyed with onomatopoetic combinations of letters combined with graphical symbols and captions. In AV productions, words and sound effects can enhance perception of the visual stimuli. However, there should be a redundant relationship between these different stimuli.



Here are examples of onomatopoetic combinations of letters.

Humour and satire

Humour as well as satire is often used in cartoons to point out a special situation, an occurrence, or an event. In instructional materials humour may sometimes be used as a visual pun to attract attention to the content or dramatize certain portions of a visual. However, humour should always be used with great care in any material for information. Misuse of humour and "funny people" may ruin the intended message. This is sometimes referred to as the "vampire-effect." Satire should usually be totally avoided in materials for information and learning.

Emotions

Visuals may express *relationships* between people. For example, in various cultures the distance between people tells the viewer a lot about their relationship; if they are friendly or hostile, and if they trust each other.

Pictures are able to express *emotions* in at least three different ways. A picture may suggest an image of some emotional concept. It may look the way an emotion feels, for example "happy" or "sad." A picture may arouse emotional response in a viewer, the viewer may feel pleasure, excitement, or fright. A picture may also express and reflect the picture creator's private feelings about a given subject, such as politics or religion.

Visuals with an emotional content support and extend the attitudes that we already have. Pictures will usually not change our attitudes, but they make us more convinced that we already hold the "right" views. If people like the content in a visual, they like it even more when the visual is presented in colour and vice versa. In the western cultural sphere, people tend to associate colours with emotions or moods in the following way. The red

and yellow part of the spectrum is often said to be warm and is felt to be active, exciting, happy, and clear. Green to blue is described as cold and are perceived as being passive, comfortable, controlled, and peaceful. Emotions and moods are readily conveyed with onomatopoetic combinations of graphical symbols. However, we have to remember that the meaning of the symbols must be learned by the readers to make any sense.

Assessing image content

This section includes a discussion of methods for assessing image content. It is relatively easy to assess concrete image content. However, it is not at all as easy to measure aspects of abstract image content. A subject matter can be depicted with many different kinds of pictures and a single picture can be perceived in many different ways. In order to be able to produce better information materials we need to study the importance of various variables in visual language. We need to further develop methods for measuring image properties.

Measuring concrete image content

The execution of a visual can be measured by objective as well as by subjective methods. However, the image content may only be assessed and measured by subjective means. Variables in visual language have functional as well as suggestive properties (Pettersson, 1989). The functional properties are related to cognitive factual information in content, execution, context, and format. The suggestive properties are related to emotions, conceptions, aesthetic perception, tension, fright, etc.

Functional properties predominate in symbols. They are also more important than suggestive properties in informative

and educational pictures, since their task is to convey certain information in the most effective manner possible. The objective for a picture for information may also be to convey certain emotions and arouse the viewer's interest and involvement (e.g., regarding conditions in other countries and cultures, or in past times).

Suggestive properties are more important than functional properties in "artistic pictures." Art is not primarily a question of objects. It is more a visual language for dissemination of ideas and experiences that are difficult to put across in words. Irrespective of the sender's intentions, different receivers may respond in an emotional manner to a picture with mainly functional properties. In the corresponding manner, some viewers may respond unemotional and functional to pictures with predominantly suggestive properties.

In the USA more than 50,000 high school, college, and adult learners have participated in more than 200 visual research studies. Dwyer has reported results from these studies several times (1972, 1978, 1982-3, 1985, and 1994). Throughout these studies, continuity was maintained by utilizing the same 2,000 word instructional unit on the human heart. Visuals range from simple line drawings to realistic photographs, in black and white as well as in colour. A variety of presentation formats, such as booklets, television, and slide-audiotape presentations have been used in these studies.

Pictures with concrete content have also been used in a number of other studies. In several experiments subjects have been given various assignments. Thus subjects have been asked to name image content, to describe image content, to index image content, to write captions, to assess image content, to

create images, to complete a story, to illustrate a story, to produce information sets, to produce information graphics and to describe picture context. See Cohen, Ebeling, and Kulik (1981), Goldsmith (1984, 1986), and Pettersson (1989, 1993) for reviews of these kinds of studies.

Pictures that are easy to read are usually rated as aesthetically pleasing and suitable for use in the dissemination of concrete information (Pettersson, 1986). Here, we often find a close agreement between intended and perceived image content. It is relatively easy to assess and measure concrete image content. However, it is not at all as easy to measure aspects of abstract image content.

Measuring abstract image content

Russel (1991) studied how individuals make sense of their world through photographs. A total of 163 children (11–12 years old) were given black and white, and colour photographs and were asked to write words and phrases which came to mind as they viewed the images. The picture elicited more than 400 different words/phrases (associations). On average, each child gave a total of 17 words/phrases. Russel concluded that photographs could provide a unique view of life, but the cultural environment and background experiences of the viewer influence the meaning in the mind of the viewer. In making sense of the world through photographs each viewer internalizes the message to personal space, time and life experiences.

Later Russel described five categories for viewers contributions to photographs (Russel, 1993). In observation the photograph is seen as a series of observable elements. In interpretation the photograph is seen as a stimulus for interpretation.

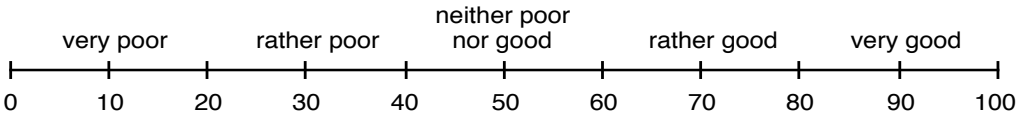
Here the viewer tries to create meaning from the visible elements. In personal memories the photograph is seen as a stimulus to recall personal experiences. In participation the photograph is seen as a stimulus for imaginative participation. The viewer is participating in the scene in the image. In medium intrusion the photograph is seen as a specific communication medium related to the photographer and to the camera.

Perceived image content

In one study (Pettersson, 1985) the objective was to examine the degree to which intended image content coincided with perceived image content. Stockholm University and RMI-BERGH, a Stockholm Art & Design School performed the study as a joint project.

The students selected five abstract concepts: 1) togetherness, 2) credibility, 3) aggressiveness, 4) courage, and 5) suspiciousness, and produced five drawings and five photographs for each topic. The pictures were all mounted on cardboard paper in the A3 format (29.7 x 42.1 centimetres). The art students and their teachers were called the "sender group" (46 persons). The members of this group individually ranked all the pictures and selected one drawing and one photograph to represent each topic. Then they individually rated how well the content of each picture corresponded to the picture's intended content on a semantic scale. The verbal ratings: very poor, rather poor, neither poor nor good, rather good, and very good, were supplemented with a numerical scale from zero to one hundred. In this scale very poor is 10, rather poor is 30, neither poor nor good is 50, rather good is 70, and very good is 90. This type of combined verbal and numerical scale had been used in previous studies

(e.g. Gabrielsson et al. 1983, Pettersson et al. 1984), since it makes possible statistical analysis of verbal ratings.



This is a combined verbal and numerical semantic scale.

Later representatives (40 university students, and 40 high school pupils) for intended "receivers" individually rated perceived image content of the pictures according to the same semantic scale. The results showed that 1) a subject matter can be depicted with many different kinds of pictures, and that 2) a single picture can be perceived in many different ways. There was poor agreement between the intended and the perceived interpretations of these abstract image contents. The drawings conveyed intended messages somewhat more successfully than the photographs. The results also suggested that "qualitative" picture studies must be undertaken with great caution, since people perceive the same picture in so many different ways. It seems that the only way to assure that information conveyed by pictures is clear and unambiguous is to provide a caption for each picture.

According to the sender group, most of the pictures were about "rather good." Eight pictures received mean ratings from 63 to 75. One was rated lower (57) and one was rated higher (85). Relatively large standard deviations (around 21) reflected large inter-individual differences in the subject ratings. In nine out of ten cases, there was no difference between the female and male members of the sender group.

The university students matched the sender group fairly well in terms of age structure. However, their perception of the pictures differed. One of the pictures was assigned a higher rating, three were rated the same, and six received lower ratings. An even greater spread in standard deviations (17–27) indicated wider inter-individual variations in ratings. A gender-based analysis of the ratings disclosed that the females in the sender group and the female subjects in the receiver group were in much greater accord than the corresponding male groups. The women rated four pictures differently, and the men rated six pictures differently. High school pupils' ratings of five pictures were significantly different from sender group ratings.

In a follow-up study, slides were made of the five drawings. These slides were then projected to and rated by 113 adult subjects at the UREX image laboratory in Finland. The subjects in Finland rated the pictures very much the same as the subjects had done in Sweden. In Finland 68% of the subjects rated the images as "rather good" or "very good" according to a Likert scale (very poor, rather poor, rather good, and very good). The abstract image content was more important for the subjects than the format of the images.

Under-evaluation of pictures

Weidenmann (1989) studied under-evaluation of pictures. In an experiment, 206 male students rated the "perceived quality" of five materials on leadership. The five versions were:

1. Text
2. Text with "imagination instructions"
3. Text with pictures and no instructions
4. Text with pictures and picture-oriented instructions

5. Text with pictures and imagination instructions

The "illustrated text with picture-oriented instructions"-group rated the material more positively with respect to four factors: 1) comprehensibility, 2) concreteness, 3) attractiveness, and 4) memorability. The three groups with instructions in their texts each rated the material lower in scientific "seriousness" than did the two other groups. After two weeks 159 subjects received a questionnaire concerning main ideas and details of the text. Results showed that the "illustrated text with picture-oriented instructions"-group recalled significantly more main ideas and details of the text than did all other groups. The differences among the other four groups were statistically equivalent. It can be concluded that an under-evaluation of pictures can be compensated for by explicit picture-oriented instructions. In materials for information and instruction (all) pictures need captions.

Image associations

In order to further observe what kind of interpretations pictures may cause in different people I designed and conducted another "Image association study" (Pettersson, 2001a). The main hypothesis was that different assignments to a picture would influence the meaning in the mind of the viewer.

When we ask people a basic question like: "What does this picture represent?" we should expect to get the same answer from different persons in the same cultural environment. This should be an answer on an "immediate level interpretation." At least we should expect to get rather similar answers from different persons. These answers might be rather short and distinct. The same words would be used by a large number of people.

However, when we ask people a question like: “What do you think of when you see this picture?” we should expect to get a large number of different answers. This should be an answer on an “analytic level interpretation.” These answers might be rather long and elaborated and subjects would be expected to use many different words. For this specific study I used the following five questions:

- What does this picture represent?
- What happens in the picture?
- Where did you first look in the picture?
- What do you think of when you see this picture?
- Why do you think so?

The subjects were also asked to write a caption to each picture. To avoid any copyright problems I selected nine of my own photographs from our own ”photo album” to be used in this study. All photographs are highly realistic and they are all in colour. The selected photographs represent a range of themes from many different activities and places, and they were randomly assigned a number. These nine pictures could well be used in various information materials and textbooks. The intended image contents are:


1. This is a group of five lemurs at Skansen, the zoo in Stockholm.
2. This is the Niagara Falls in Canada.


3. This is a Chinese carnival in Washington DC, USA.
4. This is a part of a park in central Stockholm.

5. The harbour in Stockholm. 6. Busy traffic in Athens, Greece.

7. This is an airplane at the airport in Jackson Hole in USA.
8. This is a dead bird washed up on a sandy Japanese beach.

9. This is Pont du Gard, an old Roman aqueduct in France.

The first idea was to show all pictures as slides in class and collect written statements from our student subjects. This would, however, limit the possibilities for individual students to spend the time they felt they needed for each assignment. To avoid this situation we used Internet as a research tool.

All pictures were scanned and made available on a temporary class Web Page on the Internet. The pictures had been numbered at random and had no captions. Students taking an introductory course in Information Design were asked to study

each picture and answer the above questions on e-mail. The students sent an e-mail for each picture to my research assistant with answers to all the questions. The students were free to spend the time they needed for each assignment. They could easily enlarge the pictures and study various details if they wanted to do so. The research assistant then opened e-mails from more than 100 students and copy some 4,500 statements into separate word-processing files for each question. The participation of each student was marked in a log. After this moment it is no longer possible to link any statement or opinion to any specific person. The next step in the process was to classify and group the opinions expressed by the subjects. This method with collection of research data using the Internet worked well. Since computers build the pictures line by line from the top left corner we had to exclude the third research question from the study. It was not possible to look at the picture in other ways than from the top left corner down to the right.

Depending on the character of the various assignments subjects used different number of words in order to express their opinions. Pictures 1, 3, 4 and 7 form a natural group (group 2). These pictures all include "faces" and they cause more words per answer (M=9.1) than the "technical pictures" in the first group (M=7.6). Question 1. "What does this picture represent?" and question 3 "What do you think of when you see this picture?" need a smaller amount of words than question 2 "What happens in the picture?" and question 4 "Why do you think so?" Answers to the first question are usually focused on the actual image content, while answers to the other questions quite often deal with personal associations caused by looking at the pictures.

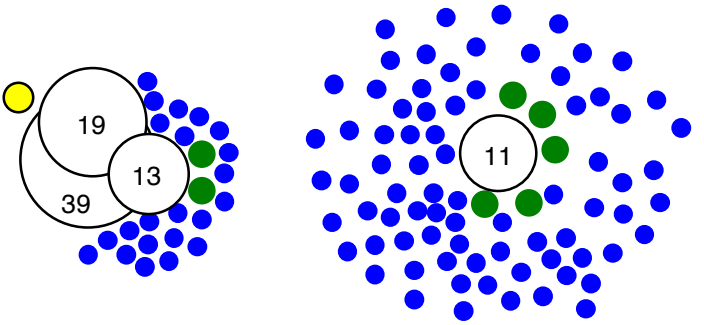
In order to be able to compare the diversity of the opinions about the pictures I have calculated a simple index. This index is calculated as the sum of the five most frequent explanatory words expressed as a percentage of the whole number of words for each picture and each question. High index values indicate that many subjects have the same opinions, expressed by words redundant to the image content. Low index values show that people have many individual opinions expressed with different kind of words.

As we would expect group 2, the "face group" (M = 11) have lower index values than the "technical pictures" in the first group (M = 17). People are interested in faces. This is known in the literature. Pettersson (1993, p. 225) noted: "Generally speaking, humans, especially their faces, are the kind of content that will get maximum attention in images."

The results clearly show that the first question "What does this picture represent?" has the highest mean index values. It is obvious that pictures 2 (Niagara Falls) and 8 (Dead bird) may contain fewer details of interest to the subjects or details that are confusing to the subjects. The following questions, "What happens in the picture?" "What do you think of when you see this picture?" and "Why do you think so?" have a declining level of consistency or an increasing number of individual expressions.

When people express similar views and similar opinions they may sometimes use exactly the same words in the same sentences. However, they may also use synonyms, near synonyms and related words to express what they mean. Some expressions may be different but at the same time express a kind of "kinship" with one another. Thus, from a practical point of

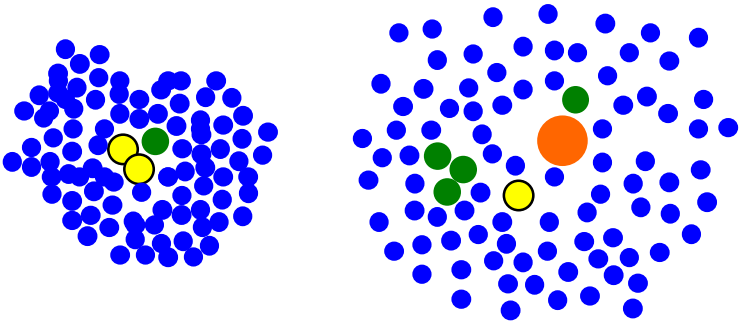
view, rather different paragraphs of texts may convey "the same" message. If all subjects in a study provide exactly the same answer to a question this can be represented in a diagram with one large circle. If all subjects provide their own, individual answer to a question this can be represented in a diagram with one hundred small circles evenly distributed in the diagram. I have named this kind of diagram kinship diagram.



This is the Niagara Falls (picture 2). The left kinship diagram presents the answers by 100 subjects to the question "What does this picture represent?" The three large circles represents 39, 19 and 13 answers respectively. The diagram to the right presents the answers by 98 subjects to the question "What do you think of when you see this picture?" Here the large circle represents 11 answers. Each one of the small blue circles represents one answer, the green two, and the yellow three.

If we put the circle representing the largest number of views and opinions in the centre, then use the direction and distance as variables to subjectively represent the kinship between these opinions it is possible to visually compare results from the different assignments. This is quite possible to do. The index va-

ries a great deal between the various pictures. The first two questions: “What does this picture represent?” and “What happens in the picture?” cause fewer opinions than the following two questions: “What do you think of when you see this picture?” and “Why do you think so?”



This is the Chinese carnival (picture 3). The left kinship diagram presents the answers by 100 subjects to the question “What does this picture represent?” The diagram to the right presents the answers by 102 subjects to the question “What do you think of when you see this picture?” Each one of the small blue circles represents one answer, the green two, the yellow three, and the orange five.

Sometimes it may be quite difficult to decide how an opinion should be classified. Generally speaking it was more difficult to classify pictures with people and the picture with the lemurs than the other pictures. It is obvious to me that different people may do this kind of classification in different ways. However, they will all end up confirming the notion of a denotation, i.e., a literal meaning for a picture, and various connotations, i.e., associative meanings from that picture, and then also some vari-

ous private associations for each picture. When we compare the mean number of denotations, connotations, and private associations for all of the nine pictures it is clear that the opinions expressed are influenced by the assignments. The first two questions "What does this picture represent?" and "What happens in the picture?" have a large number of denotations. The other two questions: "What do you think of when you see this picture?" and "Why do you think so?" have a large number of private associations.

More than 5 000 statements from more than 300 subjects show that pictures can generate a great variety of associations in audiences. How we actually create meaning is an area where much research still is needed. It may, however, be concluded that:

- Different assignments to a picture will influence the meaning in the mind of the viewer.
- Realistic photographs can generate a great variety of associations in audiences. Visual experience is subject to individual interpretation.
- Humans, especially their faces, are the kind of image content that will get maximum attention.
- Quite often perceived image content is different from intended image content.
- In information design it is not sufficient merely to choose and use good pictures. Pictures used in information and instructional materials always should have captions to guide the understanding of their intended content.

Measuring the importance of means of production

The introduction of personal computers and different software packages has changed the way many people work. This is true for writing of text, and also true for the production of many kinds of visuals. We can change the typography of text and thus adopt the legibility of that text for different media and for different audiences. But how do people perceive text and pictures with different styles that are dependent on the means of production?

Objective

In a study at the department of Information Design at Mälardalen University, Sweden, the objective was to *examine if the means of production of a message will influence our perception of that message* (Pettersson, 2000). The specific question was: "Are there any general differences between traditionally hand-made and computer generated pictures?" The hypothesis was that computer generated pictures will provide a "better experience" for the receivers than hand-made pictures with the same subject matter. We anticipated that receivers should find that computer generated messages will provide better legibility, better readability, better reading value, better aesthetic value, optimal complexity and better credibility.

There are a number of sources of possible errors for all qualitative studies of pictures and visual language. It may be hard, or it may even be impossible to draw any general conclusions from a limited number of experimental pictures and a limited number of subjects, selected at random. The skill of individual fine artists and illustrators will probably influence the

quality of the final pictures. Receivers will probably always have their individual preferences and interpretations with respect to the visuals that we use for information. If a teacher acts as a leader for a visual language experiment this may also influence student subjects. However, we designed this study in order to reduce the importance of these problems.

Experiment

The "sender group" (36 illustrator students) selected six topics for an information material, a message: 1) a city plan showing the location of the Department of Information Design, 2) the information design program for illustrators, 3) the development of rust, 4) student admissions to the programs in information design, 5) the life of the flea, and 6) the Rothof City Park in Eskilstuna. Each member of the sender group selected one topic and then produced one traditionally hand-made picture in colour, and also one computer generated picture printed with a colour-printer. All these 72 pictures were mounted on cardboard paper in the A3 format (29.7 x 42.1 centimetres) together with their captions.

The members of the sender group individually ranked all verbal and visual messages and selected one to represent each topic. Then they individually rated how well the content of each message corresponded to its intended content on six semantic scales, adopted for each hypothesis. Administered by a research assistant 26 of the senders made a total of 1,872 ratings. For each scale the verbal ratings were supplemented with a numerical scale from zero to one hundred. Later the intended "receivers" (47 other information design students) individually rated the perceived content of the messages according to the same

semantic scale. The receivers made a total of 3,384 ratings. Thus the project included 5,256 ratings. The statistical analysis showed the hypothesis to be true. In this study the means of production influenced the perception of the messages. Subjects seem to “like” or “dislike” an information material.

A 2x2x2x2x6 analysis of variance with group (sender, receiver), ill_ed (illustrator, editor), and gender (male, female) as grouping factors and means of production (manual, computer generated), and topic (city plan, program, rust, admissions, flea, and the park) as repeated factors. A factor analysis of all the data showed that legibility, readability, reading value, aesthetic value and credibility all were rated in a similar way. These factors represent a general attitude towards the messages. Each message was judged somewhere on a “poor to good-scale.” The subjects in the sender group as well as the subjects in the receiver group liked the computer-generated pictures ($M = 62.5$) better than the pictures produced in a traditional manner ($M = 57.8$). Thus computer-generated pictures were better than traditionally produced pictures [$F (1, 66) = 9.59$; $p =. 003$]. The difference is small, but statistically significant.

Regardless of the means of production the assessments of the various topics were significantly different [$F (5, 330) = 19.85$, $p < .0001$]. The subjects in the sender group were more pleased with the information materials ($M = 61.9$) than the subjects in the receiver group ($M = 59.1$) [$F (1, 66) = 3.94$; $p = .051$]. This corresponds well with the previous study of intended and perceived image content. Ratings made by females ($M = 61.9$) and males ($M = 57.2$) disclosed that the females in the sender group and the female subjects were in greater accord than the corresponding male groups [$F (1, 66) = 5.90$; $p = .018$]. How-

ever, the difference is small. This was similar in the previous study of intended and perceived image content.

There were no differences between the two means of production for the complexity factor [F (1, 66) = .02; p =. 9]. However, there were clear differences between the topics with respect to the complexity factor [F (4.03, 265.8) = 3.2; p = .014]. In this scale pictures with low ratings are complex and they have many details. Less complex pictures have fewer details and they get high scores. In this study most pictures were rated close to the middle value "neither complex nor simple." The assessment of the complexity factor varied with the gender of the subjects [F (4.03, 265.8) = 2,68; p = .032]. The female subjects (46.9) assessed the pictures as less complex than the male subjects (44.8) did [F (1, 66) = 5.23; p = .025]. As the case with the good poor scale the sender group (47.9) assessed the complexity factor as different from the assessment of the receiver group (45.1). [F (1, 66) = 6.48; p = .013] However, both groups are close to the value of "neither complex nor simple." The mean assessments for the six different topics were: city plan 51.4, program 41.9, rust 42.7, admissions 47.5, flea 46.7, and the park 46.6.

In conclusion it is relatively easy for subjects to assess concrete image content. However, it is not at all as easy for subjects to assess and to measure aspects of abstract image content. The results from these experiments and studies showed that a subject matter can be depicted with many different kinds of pictures and that different subjects can perceive a single picture in many different ways. In these studies content was more important than format. In materials for information and instruction pictures usually need to have captions. In order to be able to

produce better information materials we need to study the importance of various variables in visual language. We need to further develop methods for assessing and measuring of image properties.

Symbolism

As mentioned earlier, there is often a major difference between the denotation, the literal meaning, and the various connotations, associative meanings, and private associations. Many visuals have a symbolic content and meaning. Look at images used in most religions, in folklore, in mythology, in propaganda, in advertising, and in political campaigns. Some contemporary photographs and paintings are well known by people all over the world. A photograph with a national flag is much more than an ordinary photograph. To every person the flag of her or his nation is a symbol that means “my country.” A lion is the symbol for courage, a lamb suggests gentleness, and the dove with an olive branch symbolizes peace. Sometimes symbolic pictures are simplified to symbols. Visual details are reduced to a minimum. A symbol cannot have detailed information.

Viewer completion

Experienced artists usually leave out most details in their pictures. They have the ability to simplify and in the process, expose significance. They only draw the lines that are necessary to understand the intended content. Our minds constantly fill in missing details and complete images, most of the time without our realizing that it has happened. The most probable interpretation of the message is created as a meaningful whole. However, the human imagination may be triggered by the design to

provide details that will increase viewers' attention and possibly also facilitate learning. In drawings the lines that are missing may be as important as those that actually are there. This is often seen in cartoons.

In illustrations some lines are more important than others at giving key information. This is clearly shown in these simple examples of squares and triangles. Our minds fill in missing details and make the best possible interpretation of any given stimulus.

Context

A context perspective on information design includes 1) the internal context (inner context), 2) external context (with close context and social context), and 3) personal context. Each context will influence the interpretation of the message. Graphic design is a tool with which we can manipulate the raw materials–words in different typefaces, sizes, styles, empty space, illustrations, colour, paper and ink, and the final number of pages–to achieve the best possible communications between people. Most people read instructional materials selectively.

Readers rarely, if ever, begin at the beginning and read straight through to the end. Usually we use a combination of browsing, reading headings, looking at illustrations and captions, reading certain parts carefully, skimming others, and

avoiding some parts completely. Keller and Burkman (1993) noted that it is important to create a positive impression and give courseware a comfortable image to gain and maintain learner attention and to build confidence.

The goal for graphic design should be clarity of communication. Typography for information, or typography for instruction, aids communication and is also aesthetically pleasing. In this section different aspects of typography, page design, and layout will be discussed. Some guidelines for "good" typography will also be presented. Many of these guidelines are based on practical experience rather than on formal, empirical research.

Different contexts

In books the internal context is the interplay between texts, illustrations, and layout. Movies and TV programs have sound with speech, music, and sound effects plus visual and audio metaphors. Some computer programs contain advanced animation with interaction between text, images, and even sound.

The context in which a visual message is presented has a major impact on the way the message is perceived. For example, the context may consist of text, speech, music, sound effects, or other visuals. Our attention is on either the sound or on the image when we view a film or a TV program. This is even more obvious when we look at a multi-image slide and film presentation. As soon as the film starts, our attention is directed towards the movement in the film from the surrounding stills. It is just impossible for viewers not to be influenced by the film.

Our perception of a stimulus is thus not only determined by the characteristics of the main stimulus but also by those of the context. This is, however, not the case with young children. A

background, which might give extra information to an adult reader, cannot be assumed to fulfil the same function for a child. It may actually hinder the child from perceiving the picture at all.

The same pattern is identified as the letter "B" in the first sequence and as number "13" in the second sequence. Context is important for our perception.

We know that contextual variables influence perception of brightness, colour, motion, pattern, shape, and size. One and the same visual can be perceived in different ways in different contexts. A single picture taken from a series of pictures may be hard to decipher, but the visual's content becomes easier to comprehend when that picture is returned to its proper sequential context. Thus, we should be very careful in selecting contexts for our messages.

Several factors can be regarded as external context variables. In an oral presentation the audience is influenced not only by the presenter and her or his projected images but also by other things like the temperature, the furniture, the room itself, outside noise, noise from the projector, and noise from other persons. The lighting conditions may be the most important variable for our perception of all kinds of images. A projected image is perceived as having high image quality in a dark room. When the light increases, the perceived quality decreases. A printed image is perceived as having high image quality in a

light room. When the light decreases, the perceived quality decreases.

A “poor” slide will always give a poor projected image, which will be perceived as having low quality. A “good” slide with high quality content and execution may be perceived as having anything between low and high quality. When a “medium good” slide is projected under optimal conditions, that image may be perceived as better than a “good” picture which is projected under poor conditions.

The listeners usually have very small or no possibilities to influence the lighting conditions or other contextual variables in oral presentations. When there is too much light in the room the images will be poor. However, when we watch television or read a book, a magazine, or a newspaper, we can usually control and adjust the context lighting.

In graphical media the reader usually can spend, as much time as she or he feels is needed to read the text as well as the pictures. This is also true for video. The viewer is usually free to stop the tape and look at a specific sequence several times. However, in oral presentations, in films, and in television, the viewer has to follow the pace set by the sender or the producer. It may sometimes be very hard to follow a presentation and be able to accurately read the image content. Also, in oral presentations it is important to find the optimal pace. A slide should not be on too long or too short. Quite often it is the length of the text that decides for how long a specific image is used.

Layout of text and pictures

A layout is the result of graphic design. The purpose of this work is to find a suitable presentation for the content with respect to

the receiver, the subject matter, the medium, and the financial situation. Within a given area–such as a page in a book, a poster, or a label–the designer may distribute text, picture, and background (margins, space, and patterns and designs without any significant picture elements). See Part 4 Graphic Design for further information about typography, layout of text and pictures.

Execution of visuals

Informative pictures should always be designed so they are easy to read for the intended audience. The goal should be *clarity of communication*. Several authors have argued, "Form follows function." Industrial products are often shaped by what they do. To make life easier we want to have products with as good a function as possible. However in message design the subjective tastes of the individual designers are often allowed to dominate, sometimes with a serious malfunction as a result.

Basic elements (dots, lines, areas and volumes), size (picture, subject, depth), shape (external and contour), colour (hue, value, gray scale, saturation and visibility), contrast, texture, light (outer and inner orientation), emphasis, composition (organization, balance, centres of interest and direction), perspective (depth, angle of view, levels), technical quality, pace, speed changes (slow, fast), editing, zooming (in and out), panning, visual complexity and visual effects are examples of pictorial factors and pictorial components.

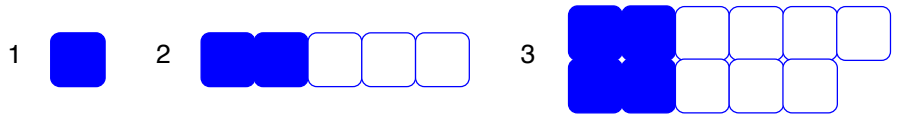
Basic elements

Vassily Kandinsky (1866–1944) was an influential Russian modernist, and pioneering painter and art theorist. He is considered by many to be the father of abstract art and a leader in the movement to free art from the strict bonds of tradition. According to Kandinsky art is the expression of the spiritual atmosphere of a certain period. Art evolves from the culture that inspires artistic expression. The foundation of forms, the harmony of colours, and the principle of art is an "inner necessity,"

or a “right of the artist” to unlimited freedom. Art is born from the inner necessity of the artist.

In 1925 Kandinsky published his thoughts of the role of the point, line, and other key elements of non-objective painting. A point, a small bit of paint on the canvas, is neither a geometric point nor a mathematical abstraction. It has colour and a simple or complex shape. A point can be isolated, or it can resonate with other points or lines on the canvas. A horizontal line corresponds with the ground. A vertical line corresponds with height, and offers no support. A diagonal line is un-stable.

Kandinsky taught at the Bauhaus school of art and architecture from 1922 until the Nazis closed it in 1933. He then moved to France.



A dot 1) may vary in size. A line 2) may be defined as a dot that is extended, at least to the length of two dots, and usually into many more. An area 3) may be defined as a line that is broadened. Thus, the smallest line possible has the length of two dots, and the smallest area possible has the size of four dots.

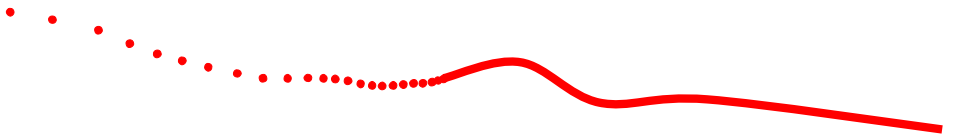
The simplest components in a picture, i.e., its basic elements or graphic elements, are *dots, lines*, and *areas*. The dots, lines, and areas can be varied and put together in many ways. Obviously, the borders between the various graphic elements are not at all distinct. Three-dimensional visuals also have *volumes*. Dots, lines, areas, and volumes all have various properties, and together they build up the visuals.

The simplest image components should be arrayed so that the picture's message is brought out as clearly as possible. This can be combined with high demands on aesthetic quality. However, it is difficult to make any general recommendations on how various drawing styles should be used. Fine details in the texture of a drawing disappear in the dot screen structure of the printed image. Even more detail is lost in a television image and an image on a computer screen. In order to save money, pictures could be tailored to the technical limitations of the systems that are used to make originals, masters, and print runs in the respective medium/distribution channel.

Hansen (1999) created a set of six tools to be used for graphical displays. Her six tools are circle or curvoid, square with right-angle corners, and square with round corners, triangle, line, point, and fuzz (dark, scribbled lines, a blur, blob, or blotch. All tools can be combined in various ways.

Dots in visual language

A dot is the smallest graphic element in visual language. The dot is usually a meaningless or a non-significant image element but it may be a syntagm, such as an eye in a cartoon-face. A dot may even have a complete meaning, such as a ball in midair. It all depends on the situation depicted. With respect to the technique and the different types of visuals, dots can vary in colour, grain, position, shape, size, as well as value. Also the context of dots will vary. A dot can provide harmony or stress to a given composition.



When dots are close to one another they form a line.

A group of dots may suggest motion and direction in the picture. The ability of a series of dots to direct our attention is greater the closer the individual dots are to one another. When the dots are really close to one another, they cannot be individually recognized any more. A series of dots form a line. A line could also be defined as the "track of a dot in motion" or as a "visual record of the path of a dot".

In *mathematics* a *point* is a *location*, defined by the crossing of two very thin lines. Any point has an exact position in a specified context, an exact coordinate on a plane. The mathematical point has no size, no shape, no colour, no value, and no grain. However, for practical reasons the mathematical point is often represented by a visible and printed *dot*.

In *printing technology*, graphic elements may be defined as type for letters, and lines, and screen points for all kinds of visuals.

In work with *digital images* in computerized image processing, graphic elements can be defined in one of two systems: either 1) mathematically as points and vectors, defined by Cartesian coordinates, or 2) in the form of pixels (minute rectangular picture elements used in "building blocks"), defined by raster coordinates. A vector can be assigned basic graphic properties in the same way as attributes in display fountains, but it has as such only mathematical properties. A pixel is in fact a minute

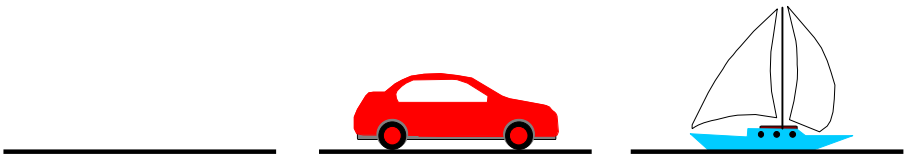
area and can vary with respect to colour. Dots, lines, areas, and symbols (such as letters) are composed of several pixels.

When we look at a printed picture, a television image or an image on a computer screen, our minds combine the dots by blending and organizing the patterns into correct images. This subconscious process is called *visual fusion*. When placed in patterns known as "halftones," printed dots are perceived as continuous and solid values and hues.

Lines in visual language

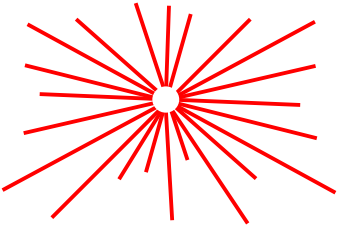
A line may be varied with respect to its starting point, its brightness, colour, context, curvature, direction, evenness, grain, length, orientation, points of change, printing, shape, thickness, value, and terminus. The line is a powerful graphic element. People have a tendency to follow a line along its way. As a result lines can be used to direct attention to specific picture elements.

The line provides the essential elements for perception of motion in a visual. Since we read from left to right, and from top to bottom in the western cultures most people here will see the upper or left end of a line as its beginning and starting point, and the lower or right end as the ending point or terminus. A line can also be a border between two areas in a visual, and separate, and group picture elements. Since we always perceive graphical elements with respect to the context, the meaning of a simple and single line will vary. A horizontal line can serve, e.g., as a horizon, a street, or a sea.



A simple horizontal line can serve, e.g., as a horizon (left), a street (middle), or a sea (right).

Horizontal and vertical lines, parallel to the borders of the picture, give the impression of calm and stability. Horizontal lines are restful and relaxing and create a strong sense of equilibrium in any composition. Horizontal lines are perceived as being shorter than equally long vertical lines (Thurstone and Carraher, 1966, p. 27). According to Lanners (1973, p. 66) horizontal lines seem shorter to us than vertical lines because the eye movements required scanning horizontal lines are easier to execute than up-and-down eye movements. Vertical lines are also symbols of power. They often stop the eye movements.



Diagonal lines disrupt harmony and add a feeling of depth to a visual. Reaching out from one point diagonal lines may be perceived as aggressive and violent.

Diagonal lines are unstable and attract the eye. They give the impression of movement, creating visual stress. Artists may use this implied motion when they wish to convey energy or action in their works. There is a tendency for curved lines and smooth shapes to stand out more than straight lines and shapes made out of straight lines. Lines that reach out from one point

in different directions may be perceived as aggressive or violent. A thick and heavy, or bold line is more powerful and strong than a thin line. In picture elements for schematic pictures it is usually better to use a solid and continuous line than a line filled with a texture or some kind of screen raster.

Artists often use several different kinds of lines in the same picture. If all the lines have the same thickness and tone, the picture may seem "lifeless" and rather boring. It is possible to show importance using different weights, or line thickness. A thin and light line is like a whisper. A bold and heavy line is like a "shout," or a "yell." Depending on its boldness, and looseness a line may express a wide variety of emotions. In many situations it is important to differentiate between lines in illustrations. In schematic pictures 0.5, 1, and 2 points are usually suitable gradations for line thicknesses for copied documentation. We can't easily distinguish between more than three or four line thicknesses in the same picture. It is often said that Picasso was a "master of line." There is a special elegance in the way he expressed the topography of the world.

As a rule, a three-step gradation is sufficient to differentiate between lines that illustrate different information in a technical illustration. The number of line thicknesses may increase in printed materials. Tufte (1997, p. 73) suggested the design strategy of the smallest effective difference: "Make all visual distinctions as subtle, but still clear and effective." For overhead transparencies the corresponding gradation of line thicknesses is at least 1, 2, and 3 points. However in a large auditorium, with a great distance between the screen and the people at the far end of the room we may have to use 2, 4, and 6 points, or even

thicker lines. In most situations we should avoid too bold lines, we do not have to shout at the audience.

According to Tufte (1997, p. 74) the "idea of the smallest effective difference helps in designing the various secondary and structural elements in display of information—arrows, pointer lines, dimension lines, tic marks, scales, compass roses, broken lines for incomplete elements, grids, meshes, rules, underlines, frames, boxes, compartments, codes, captions, highlights, accents, bevels, shadows, and fills defining areas and surfaces. Muting these secondary elements will often reduce visual clutter—and thus help to clarify the primary information".

In schematic pictures we should usually use continuous lines. We should avoid the use of various screen patterns, especially those that are screened diagonally. Lines should usually be solid and continuous and not filled with a texture or screen raster. Lines screened diagonally are often diffuse and indistinct, and are sometimes not legible at all.

If screens must be used in lines, the thickness of the screened lines should be at least 4 points, preferably even thicker, to be seen clearly in the printed material. In overhead transparencies we can use even thicker lines.

Be careful how you place graphical picture elements in schematic pictures. An important rule to consider in information design is: 1 + 1 = 3, or sometimes even more. Two black lines that run closely parallel to each other can easily be interpreted as three lines, two black lines with a white line between them.

Two lines may be seen as three lines; in this case we may see two red lines and one white line between the red lines.

Two lines that cross each other can be interpreted as four lines. They may even be perceived as four rectangles or four triangles. Too many lines can cause disturbing interference effects. We should restrict the number of lines to a minimum in each picture.

Lines that connect different picture elements or show a particular relationship in schematic pictures can be shaped differently or placed in different ways. However, this should be done in a systematic, and carefully prepared way. When lines connect to other picture elements, the connection should be distinct, without unsightly or misleading "looseness."

Sometimes several parallel lines may be required for the connections. These lines may be similar or dissimilar. Lines can link together the geometrical mean-distance points of the elements of a picture. This first method can be used for all types of geometrical shapes: such as ovals, circles, triangles, rhombi, squares, rectangles, etc.

In the second method, the lines link together the focal points on the sides of the picture elements. Linkage of the focal points lends balance and harmony to the schematic picture.

In the third method, the points of linkage are equally distributed along the sides of the picture elements. This method is appropriate for all picture elements with right angles, but the method is difficult to use if the picture elements are rounded in shape, such as circles and ovals. Preferably, the various meth-

ods should not be mixed–in any case, not in the same schematic picture.

Lines that are meant to show a flow of events should display one ore two arrowheads that proceed from one picture element and point to another. Arrowheads can have different forms. The connection to the shaft can be perpendicular, concave, or convex, and the length of the head can vary. To achieve unity we should avoid mixing various types of arrowheads in the same schematic picture. The perpendicular connection works well enough. Two-way arrows are only used for specific purposes. There are several good reasons for using lines in drawing.

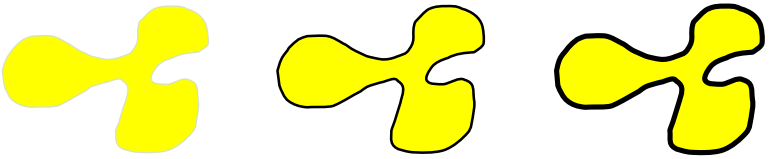
- Line is the natural way to draw. Infants begin with line and adults continue throughout life.
- Line drawings are the most readily recognizable form of depiction in general.
- Line is a quick way to visualize ideas.
- Line needs a minimum use of time and material.
- Line drawing materials are least expensive.
- Line emphasizes the basic structure and composition of a drawing.
- Horizontal lines imply calm and stability.
- Horizontal lines are perceived as being shorter than equally long vertical lines.
- Most lines are restless and never static, and may imply motion and action.
- Other drawing techniques may be added.
- Lines can connect different picture elements in schematic pictures.
- Line can take many different moods.
- Line is a tool for notation systems.

- Line describes shape.
- Line drawings are effective stimuli for learning. Line drawings are most effective in formats where the learner's study time is limited. More realistic versions of artwork, however, may be more effective in formats where unlimited study time is allowed.

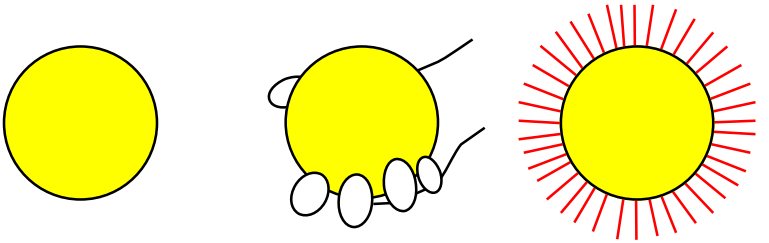
Areas in visual language

An area can be varied with respect to brightness, colour, colour combinations, context, "emptiness," grain, grey scale, shaded or non-shaded, shape, size, texture, and value. Roundness is the most common form in nature. When ink, water, or any other liquid material is dropped on a surface, it assumes a rounded form.

The American painter Chuck Close has made some portraits using his own fingerprints. These pictures are built up by thousands of small "areas." A line forming a shape may describe an area. It may also be described by a shade or by a colour. An area may have an abstract, a geometric, or a representational shape. In art shapes are often used to represent the real world. Picture elements with bold lines are perceived as more important than picture elements with thin lines.



Here are three examples of ways to delimit an area.



The size of a circle means little to us. A hand (middle) gives the circle the size of a tennis ball (middle). Lines around the circle make it the size of the sun (right).

In schematic pictures we should avoid using more than five colours, grey tones, or screen patterns in different areas in the same picture. Appropriate scales might be: 1) white–grey–black; and 2) white–light grey–grey–dark grey–black. When the final production is made with copying machines we should usually use only the first of these two scales. To the extent that colours are used, they should be clear and distinct, and they must be chosen with great care. Squares and rectangles are rare in nature. The size of an individual area is always relative. It depends on our knowledge of its surroundings. A square is an example of a static area. A rectangle is perceived as more active.

Emptiness or space is the part of a visual that is not filled with picture elements. This part of the picture is called "negative space" or "passive space." The negative space is usually the background. Space has no meaning in itself, but it may be used to separate or bring together different picture elements. The areas representing different objects are called "positive space" or "active space."

The most important elements of the visual may be emphasized so as to enhance attention and perception. We should

design all visual materials taking into account dots, lines, and areas, so that the important content will stand out and be easy to perceive.

Volumes in visual language

A volume has a three-dimensional form. The form may be actual or simulated. In two-dimensional representations of three-dimensional objects, shadows are key cues for simulated volumes. We structure the three-dimensional field into various depth planes, or grounds, a foreground, a middle ground, and a background.

Like lines and areas, volumes also have several basic properties, such as architecture, balance, colour, context, contour, direction, form, gravity, light, material, position, proportions, size, structure, stability, surface, and weight.

It may be a good idea to study the works of good artists, painters, and sculptors. Most artists use many of the possibilities in the visual language. However, some artists have made paintings, drawings, etc., using mainly one or two different elements with limited basic properties. Here are just a few examples. Vincent van Gogh only used dots and lines in some paintings. In numerous paintings, Roy Lichtenstein used the screen of dots and lines from comics in newspapers. Paul Cezanne used hues in different areas.

Pablo Picasso is most known for his paintings, in which he often used areas in different shapes. Picasso was, however, very active also in other fields. He introduced “construction” in sculpture. He assembled pieces of wood, cardboard, paper, string, and other materials. Thus, Picasso gave sculpture a potential freedom which is not yet fully explored. Marcel

Duchamp used everyday objects like the famous “Bottle Rack” directly as a sculpture. The sculptor Auguste Rodin was the master of modelling clay, with special articulation of the surface of the sculpture. Replicas of his sculptures can now be found in many countries.

The sculptor Constantin Brancusi exploited Rodin’s discovery of material as the fundamental determinant of form. He explored materials like timber and stone, and used forms inherent in these materials. He also used polished bronze. Like Rodin also Edgar Degas emphasized gravity in his sculptures. Henry Moore was a master of lines and volumes in his sculptures. In his sculptures there is an intense interaction of space, light, shadows, contours, balance, composition, proportions, relations, and stability.

Size

It is easier for us to distinguish between lines than between areas or volumes. When we judge the size of objects, e.g., areas, we are apparently most influenced by the length of horizontal lines or horizontal distances. In most contexts the differences in the sizes of circles, squares, triangles, ellipses and other two-dimensional symbols are underestimated. *Size constancy* is our tendency to judge the size of an object as the same despite changes in distance, viewing angle, and illumination.

Size of visual

In materials for information, the size of a visual should never be decided with respect to “available space” or “prettiness,” but with respect to the possibility to communicate the intended message. For example, illustrations in textbooks for early grades

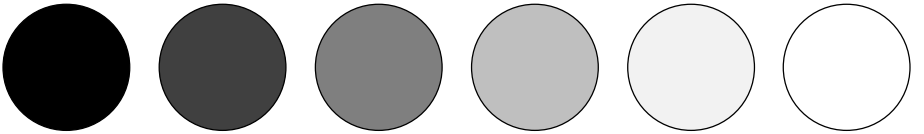
are both large and frequent. In later grades the visuals are smaller and less frequent. McDougall and Hampton (1990, p. ix) concluded that photographs needs to be presented in sizes and arrangements that will attract and hold reader interest.

Quite often readers will interpret the size of a visual as a measure of importance. By tradition the bigger a picture is on a page the more important it is considered to be. However, a visual should neither be too small nor too large. *There is an optimum size for each visual.* This size can only be established by trial and error. The size must be large enough for the image to be legible. A visual with a "large content" and many details must be larger than a visual containing a more limited amount of information. If two different sized pictures of objects are placed next to one another, one is perceived to be near the viewer and one farther away. Or the objects are perceived as being of different sizes.

If one picture is larger than the others in an array, this picture will attract the most attention. "Noise" in the visual results in a need for a larger size. A picture that is four to five centimetre (1 1/2 to 2 inches) wide in a book corresponds to the eye's perception of the width of a TV screen at a normal viewing distance and is adequate in some cases. In television the spectacle of things is de-emphasized, but human actions gain prominence. A large Cinemascope image is more overpowering than the small television image. In film, people as well as objects attain spectacular dimensions. Increasing the size of illustrations by projecting them does not automatically improve their effectiveness in facilitating the achievements of the learners.

Size of subjects

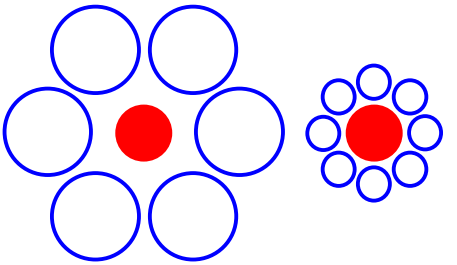
The most important part of the subject must be large and clear, take up a large proportion of the image area, and be perceivable as an entirety. Large visual elements in a picture attract the attention of the reader. The perception of size is influenced by colour and grey scale. Open and light forms are perceived as being larger than closed and darker forms of the same shape.



These circles all have the same size but we may perceive them as different because of the variation in grey levels.

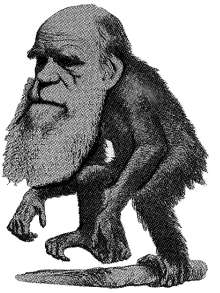
The perception of size is very much influenced by contextual variables. There can be no large without small, and no small without large. We need to show the scale and the contrast within an illustration. It is usually a good idea to include some familiar object, like a person, a tree, or a car to supply the scale for judging the size of an unfamiliar object.

Compare the size of the two red circles. The perceived size of an object is relative to the size of nearby objects. The red circle is equal in both contexts.



People vary greatly in their ability to perceive proportional relationships. The perceived size of an object is relative to the size of other objects. The size of unfamiliar objects is perceived as relative to the size of familiar objects. Sometimes it is possible to include a scale in the visual. Any simple and distinct part of an image can be visually superimposed to measure proportional relationships of the whole.

In caricatures, however, proportions are deliberately wrong. Deliberate distortions create aesthetic tension between the caricature and the normal image of the subject. This induces emotional responses in viewers. Feelings are readily aroused by a departure from what is considered visually correct or normal. Photographers can also produce "caricatures" by using unusual angles and/or distorting lenses. When we need visuals for instruction, caricatures are usually not the best choice.



This caricature was produced and published to illustrate opposition to the theories about evolution published by Charles Darwin in his work On the Origin of Species by means of Natural Selection.

When the size of an object changes in a story from one page to another or even on the same page, children up to seven years of age often believe that the objects are different.

The perception of size is related to perceived distance, and the perception of distance is reciprocally related to perceived size. Regardless of distance there is constancy in the perception

of the size of known objects. This is called *size constancy*. (See picture in the section Linear perspectives.)

Shape

When small children are scribbling they make dots, lines, and endless open circular movements (Kellog, 1959). Already three-year old kids may draw solid circles, triangles and squares (Berefelt, 1977). In my view we perceive circles, triangles and squares on a low cognitive level without any special analysis (Pettersson, 1989).

Due to their simplicity circles, triangles and squares are often used as icons or symbols in modern communication, and as picture elements in schematic pictures. However, this simplicity also means that different persons perceive simple shapes in many ways. Functional, instructive graphic symbols are probably older than words, and they are probably found in every culture however primitive.

The circle, the equilateral triangle, and the square express visual directions. Circles suggest curved directions, triangles suggest diagonal directions, and squares suggest horizontal and vertical directions. Shapes can be made in a number of ways. They may be defined as the outlines of objects, or parts from different objects. Shapes may also exist as gaps, or "negative space" between objects.

Irregular and unpredictable shapes dominate basic and regular shapes. These unpredictable shapes attract more attention than basic and regular shapes. Most people can easily perceive the basic shapes, and there is a large degree of perceptual constancy in the perception of shape. *Shape constancy* is our tendency to judge shapes as the same despite changes in dis-

tance, viewing angle, and illumination. This is one of the reasons that shapes, like the circle, the oval, the triangle, the square, the rectangle, and the rhombus often are used in symbols and icons.

For small children (three to six years), colour stimuli have greater impact than shape stimuli. However, the reverse is true of older children, i.e., shape becomes more important than colour. There is a considerable difference between the interpretation of symbols by subjects, and the intended meanings. There is no natural, spontaneous and unambiguous correlation between colour and shape. However, many persons have a spontaneous and emotional response to shapes. Some people view a square as dull, straight forward, honest, and stable. The triangle may be associated with antagonism, arrowheads, cracked ice, danger, fire, thorns, and twisted metal.

Our presumed connections between shapes and emotions are utilized by the advertising industry. Based on the stereotypes about women and men bottles holding women's perfume are generally oriented to circular, and triangular shapes. A soft bottle shape is presumed to reflect the actual female body, and imply a feeling of sensuality and warmth. A triangular bottle is presumed to imply challenge, excitement, and risk. Bottles holding men's cologne are generally rectangular in shape. This shape is presumed to imply reliability and strength.

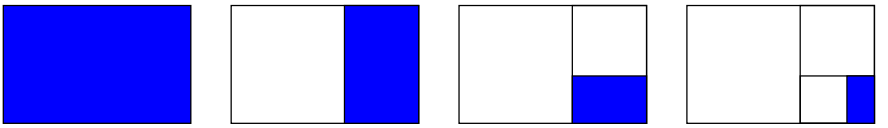
External shape

The picture area in drawing, painting, and still photography can have any shape and any orientation. Most pictures, though, are cropped and published in square or rectangular formats. However, the visual's external shape should actually rather be "free-

form," round, or oval, and not delineated by straight lines. Perception of shape is influenced by contextual variables.

Classical formats are based on the proportions of the golden section or golden rectangle, 3:5, 5:8, 8:13, 13:21, 21:34, etc. The proportions of the golden section are 1:1.618.

Television as well as film screens are horizontally oriented, since we basically experience the world on a horizontal, rather than a vertical, plane. When HDTV was developed it was found that people preferred the aspect ratio of 3 x 5 (the golden rectangle) or 9 x 16 (1:1.778) rather than the traditional 3 x 4 (1:1.333) ratio of the current television systems.



These are golden rectangles. An interesting result of the golden rectangle's proportions (left) is that if we draw a square (white) inside the rectangle using the short side of the rectangle as the side of the square, the remaining area (blue) will also be a golden rectangle. This process can be repeated indefinitely.

External contour

The visual's external contour should be blurred and unclear so the visual fades in and out of the background and never clear enough to stand out against the background. (However, as noted earlier the figures in the image must be clear and distinct.) A printed image should fade in and out from the (white) page and a projected image should fade in and out from the

(dark) screen. It is possible that very distinct framing diverts interest from the actual content in the visuals.

Illustrations in early European books frequently had gently rounded contours. Many artists still often draw free-form visuals which are not delineated by straight lines and which fade in and out of the background. In one study typical primary school textbooks from Ghana, Japan, and Sweden were compared. Irregularly shaped, oval, or round image shapes were predominant in the Ghanaian and Japanese books. In the Swedish book less than one-fourth of the illustrations were “free” or rounded images.

Colour

Colour can be described in technical, physical, physiological, psychological, and aesthetic terms. Wavelength, intensity, and purity are physical dimensions. Hue, value, and saturation describe what we see. Colour communicates. To some extent it is a language of its own. Colour can be used as an important and a successful part of information design.

What we see

Hue, value, and saturation describe what we see when we look at pictures as well as the real world.

Hue

When we talk about the colour of an object we usually refer to the hue of that object. Most people are familiar with hue through our labelling of colours such as red, orange, yellow, green, blue, and violet. Hue is colour. In colour description systems hues are usually placed in a band around a centre, in a

"colour-circle". (See the subsection *Colour description systems* for further information.) Different wavelengths of light reflected off an object are responsible for the hues. All of the colours in the rainbow are hues in the visible spectrum of light. It is possible for us to see the difference between several million colours.

However, we can only distinguish about 10,000–20,000 hues (Hård and Sivik, 1981) different colours, and only about seven colours in the same field of view. Yellow-green colour lies in the region of the eye's greatest sensitivity. Sensitivity decreases markedly toward the red and blue ends of the spectrum. Perception of colour is strongly influenced by and dependent on contextual variables such as lighting conditions and other surrounding colours.

A black and white picture represents reality in a different way than colour pictures. In black and white, all data about colour is translated into values of grey. Hue adds the "colour-dimension". Hue may also act as a formal element in a composition, and direct the attention of the viewer.

Value

Value (sometimes called tone) is the apparent lightness or darkness in anything that is visible. It ranges from white to black. In nature there are hundreds of steps in value. However, we can only distinguish between a limited numbers of levels of value. Pictures derive a simulated natural tone from pigment, paint, or nitrate of silver. There is an element of value in colour pictures, as well as in black and white pictures.

There are hundreds of steps in value from white to black.

In colour description systems values are usually placed on a vertical scale, from white to black. It is not at all easy to distinguish between more than ten shades of grey. In printed materials grey is a combination of black ink and white paper, measured as a percentage of full black. Bertin (1967) recommended the following steps in scales, with three to ten steps, from white (W) to black (B):

W 49 B
W 30 73 B
W 20 50 82 B
W 16 38 66 86 B
W 14 31 51 74 88 B
W 11 25 42 61 78 89 B
W 10 21 35 52 68 81 90 B
W 9 19 31 45 60 74 84 91 B

In information design, however, it is often enough to use white, black and one or two shades of grey. A grey scale can usually serve the same function as a colour scale in a map. A colour scale, however, may be nicer and more attractive. Value is more important to contrast than hue. According to Dondis (1973) the broadest range of distinctly different grey tones in pigment is about thirty-five. Without light upon it, the whitest

of whites will not be seen at all. It is also hard to distinguish between very dark grey and black.

A “high key” picture is composed with mainly light values, and a “low key” picture has mainly dark values. Value may be used to express emotions, form, space, and movements as well as to give the illusion of light. Each colour has its own tonal value. Our perception of one specific tone of grey, or any colour, can change when it is placed on a tonal scale.

Saturation

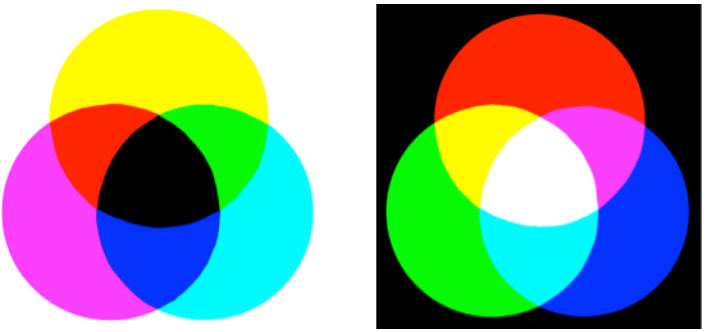
Saturation is the apparent purity or lack of greyness of a colour. A bright and pure colour is saturated and has no grey at all. A colour with some grey is less saturated. A lot of grey gives an unsaturated colour. A black and white picture is an example of total un-saturation. The amount of saturation does not influence the basic hue of a colour, and it is not related to the value. Saturation steps run out in horizontal rows, from the vertical value-scale in colour description systems. (Sometimes saturation is called chroma or intensity. However, sometimes chroma is said to be the combination of hue and saturation.)

Saturated colours are often considered to be aggressive, bold, daring, vibrant, and they may grab our attention. Unsaturated colours may be perceived as boring, dull, peaceful, restful, soft, weak, and they may sometimes be depressing. Unsaturated black and white pictures are often used to represent the past. Highly saturated colours are frequently used to depict the future. Boldly coloured objects seem closer to us than unsaturated colours. Colour variations take the natural form of a triangle, a “colour-triangle”. At the top corner is white. Black is at the bottom corner. At the third corner is the pure colour of hue. A mix

of a pure hue and white gives a tint. A mix of a pure hue and black gives a shade. A mix of white and black gives grey. A mix of all three colours gives a tone.

Colour combinations

Looking at a picture printed in colour we experience a *subtractive colour combination*. The inks, dyes, and pigments function like filters for the white light and present colour to the eye by reflection. The wavelengths of light are absorbed (subtracted) in different ways. When printing on white paper, yellow and magenta (a red-purple colour) produce red. Yellow and cyan (a blue-green colour) create green. Magenta and cyan give blue. A mix of all three primary colours will become black. The black ink gives the picture a distinct sharpness and more solid dark elements. Using the primary colours painters can mix paints of other hues.



This illustration shows a model for subtractive colour combinations (left) and a model for additive colour combinations (right).

A picture tube or a cathode ray tube is the unit that produces and shows the picture on a traditional TV-receiver, computer, or terminal screen. The picture tube consists of an airless glass-tube. Its rear end contains a device that which emits electronic rays, while the front part forms the screen. When hit by the electrons the back of the screen is illuminated.

A picture is built up by steering the ray from differently coloured light sources over the screen. In a picture tube the *additive combinations* of the primary colours red, green, and blue lights (RGB) can produce a huge range of various colours. The additive colour combination starts in dark *adding* light to produce different colours. The end result is white. In this system the secondary colours are yellow, magenta and cyan.

The coloured pixels do not overlap on the screen. When viewed from a distance, the light from the pixels diffuses to overlap on the retina in the eye. Projected additive light is used in theatrical lighting, such as concerts and plays.

Colour constancy is our tendency to judge surface colours as the same despite changes in distance, viewing angle, and illumination.

Example of colour constancy.

Brightness constancy is our tendency to judge the brightness of objects as constant, even though changes in illumination make the objects appear brighter or darker.

Colour description systems

As previously noted colour can be described in aesthetical, physical, physiological, psychological, and technical terms. Hue, value, and saturation describe what we see. Intensity, purity and wavelength are physical dimensions. The relationship between brightness, hue, lightness and saturation is very complicated. For practical use in art and in industry several different systems providing numerical indexes for colour have been developed. Examples are the *Hue Lightness Saturation System* (HLS), the *Hue Value Saturation System* (HVS), the *Munsell Colour System* (MCS), and the *Natural Colour System* (NCS).

(See the book *Information Design 4–Graphic Design*.)

Use of colour

The symbolic meanings of colour vary from culture to culture. European cultures put on black to mourn a death, while Asians wear white for the same occasion. In Western European cultures blue is a symbol for authority or calmness. Yet, in Japanese culture it connotes villainy, and in Arabic cultures blue symbolizes virtue and truth. Thus, we should be very careful when using colour in international information materials, especially when the context may suggest religious or social interpretations. It is often a good idea to design visuals that work well in black and white, and then add colour to make them work even better.

Affective use of colour

Colour enhances the attention and perception of a visual message. If people like the contents in a picture, they like them even more when the visual is presented in colour. From many experiments, it is clear that people prefer colour in visuals. Advertising is known to be much more effective when visuals are in colour than in black and white. Tests have indicated that viewers feel that they have a better understanding when television images are displayed in colour, although the use of black and white sometimes would be sufficient. However, an improper use of colour can produce negative results: it can be distracting, fatiguing, and upsetting. Yellow, orange, and red hues are perceived as warm and active. Red evokes feelings of strong emotions. Violet, blue, and blue-green are perceived as cool and passive hues. Blue is often used to represent truth and honesty. White is often associated with innocence and pureness, and black often represents evil and darkness.

Colour blindness

Colour blindness, or better still "anomalies of colour vision", is a condition in which certain colour distinctions cannot be made. This is more commonly observed among men than among women, with estimates ranging as high as 10% of the male population. Only 1% of the female population has anomalous colour vision. Failure to distinguish between red and green is most common. Both hues are perceived as grey. Common colours in graphic symbols are pure yellow, red, blue, green, white and black, or combinations of these. Unfortunately, red and green are often used as discriminating colours in symbols and in warning signs. Since many colour-blind people perceive

red and green as grey, colour can only be used to code the information redundantly. Colour may be combined with shape, and position, or with both, which is often seen in traffic signs.

Cognitive use of colour

For some learners and for some educational objectives, colour improves the achievement of the learners. However, in some cases the added cost of colour will not be justified. Colour is important in a visual when it carries information that is vital to the contents in the visual. It is, for example, easier to learn to distinguish between various species of birds or butterflies when colour illustrations are used, instead of black-and-white illustrations. Highlighted information tends to be better remembered. Colours can easily be used for highlighting, separating, defining, and associating information. In line drawings or in black-and-white photos, for example, the addition of one colour may be very efficient. To avoid confusion and misunderstanding, it is important that colour be used consistently. Colour is capable of enhancing communication and adding clarity and impact to a message. In spite of the large quantity of research, colour perception still only seems to be partially understood. It could be concluded that:

- People might see colours in the same way. However, no two persons experience colour in precisely the same way.
- The human reactions to colour stimuli cannot be standardised.
- Depending on sex, age, profession, and culture, there are different subjective reactions to colour.
- There are likes and dislikes of colour, based on general as well as personal associations.

- Colours can be associated with temperature and emotions.

Colour coding

Colours are often used for colour coding, for example, of objects and in documents. Colour coding is also used in different signs and symbols. This may improve attention, learner motivation, and memory. However, the number of colour codes should be limited and always explained. When the number of colour coded items increases, the value of colour as a cue for selecting important information decreases.

A colour-coding process may enable learners to retain critical information and disregard redundant and irrelevant information. An effective and systematic colour code, with a maximum of four to six colours, in a learning material assists the learner in organising and categorising stimuli into meaningful patterns.

To avoid confusion and misunderstanding, it is important that colour be used consistently. Inconsistent and improper use of colour can be distracting, fatiguing, and upsetting, and it can actually produce negative results and reduce learning. It should also be remembered that some people are red-green colour blind and they perceive these hues as grey.

Colour contrasts

In 1912 Kandinsky published his provocative thoughts on *colour theory, and the nature of art and beauty* (1912/1977). He studied the harmony of colours and found that colours evoke a *double effect* (pp. 23-24): (a) A purely *physical impression*, and (b) a *psychic effect* in which colour produce a spiritual vibration, and may touch the soul of the beholder.

Kandinsky discussed four main colour contrasts in paintings: (a) Yellow-blue, (b) white-black, (c) red-green, and (d) orange-purple. It seems that a warm yellow surface move closer to us, while a cold blue surface seems to move away. Green, which is a mixture of blue and yellow paints, yields calm and immobility. The white-black contrast is static. Red is an agitated and warm colour. Red and black becomes brown, a hard colour. Red and yellow becomes orange. Red and blue becomes purple. White is clarity, and a deep silence. Black is eternal silence without hope, nothingness, and obscurity. Gray has no active force, and corresponds to immobility without hope.

Colour preferences

Generally speaking people prefer surface colour hues according to this ranking: 1) blue, 2) red, 3) green, 4) violet, 5) orange, and 6) yellow. However, blue, red, and green do not improve our possibility of reading the message accurately. Children prefer colour hues that are light, distinct, and shining better than colours that are dark and gloomy. Colour intensity should be strong and colour contrast should be clear. People in different cultures and in different socio-economic groups use colours in different ways and with different meanings. In cultures in Africa, Central and South America, and Indonesia, bright colours and high contrast are common in illustrations.

Decorative use of colour

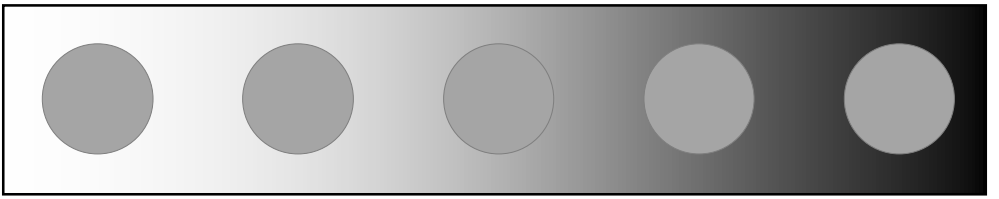
There are many situations where colours can be used for decoration. However, a decorative use of colour should never be mixed with other uses of colour. It must always be clear, and easy to understand when colour is used for decoration and when the use is meant to have some cognitive importance. This

is also true for the general structure of visuals. Most visuals are too complicated, and would communicate better if designers valued simplicity over decoration. This is especially true in electronic documentation that shall be read on a computer screen.

Contrast

In nature, as well as in art, contrast is of major importance for our perception of a message. The contrast is the difference between the brightest and the dimmest parts of a picture or of a text. The contrast should be clear and differentiate image elements from one another. This is regardless of the colour chosen, and regardless of colour-contrast effects. Visual acuity, our ability to discriminate small objects, peaks at about age 22, and then a steady decline starts. This decline is not possible to correct with eyeglasses. At about age 40 the tissues of the eyes get stiffer. This condition is called presbyopia or "old eyes." It makes it harder for us to shift the distance of our focus. Thus it is harder to change between reading on a screen and reading on paper.

Throughout our lives the lenses become less and less transparent. The result of this increasing opacity is that we require more contrast between a message and its background to see any fine details in images and to read text. The biggest offense to less than perfect eyes is a lack of contrast between message and background. Coloured text on a coloured background is a common example. Different hues may have the same value, and as a result almost no contrast. It is far too common that illustrations in textbooks and video programs do not have good contrast. Instead, it is quite often a more or less even shade of grey or chromatic colours.



Our perception of one tone of grey (circles) will change when it is placed on a continuous tonal scale.

Another common problem is the use of too small type. Text must be large enough. Also symbols are often too small. The difference in resolution in different media is very important. A typesetter can produce 10,000, a laser printer 140, and a high-resolution computer monitor only ten dots per square millimetre. For people to be able to recognize the colour of an object it should be at least 1.5 millimetres for marks on a paper and six pixels on a computer screen. Thus graphics designed for paper must usually be simplified for display on computer screens. In the comparison of the darkness of tones on a graphic display, differences in tones will be overestimated. It is known that high contrast between objects attracts attention, and children prefer light visuals as compared to dark visuals.

Texture

Texture is the visual equivalent of the sense of touch and the feel of an object's surface. From our experience we know that a sweater is "soft," a steel tube is "hard," and that a piece of broken glass has a "sharp" edge when we touch it gently with our fingertips. We can see minute variations in colour and structure of a surface. In our daily lives we have great use of our perception and understanding of texture when we look at various ob-

jects in our surroundings. Optical texture serves as a stand-in for the qualities of actually touching and sensing the real objects. Texture makes objects appear to be smooth or rough, soft or hard, heavy or light, sharp or flat according to our personal experience of these objects. We can avoid touching a hot stove. We can be very careful when we have to pick up sharp pieces of broken glass and sharp-pointed and sharp-edged pieces of metal.

Optical texture also works in visuals. In a picture a sweater and the skin of a baby looks "soft," a steel tube looks "hard," and a piece of broken glass looks sharp. In a photograph we may recognize and "sense" the hard bronze surface in a sculpture and the soft and warm yarn in a textile. The bronze surface may be perceived as warm, or as cold depending on the content, the lighting and the context in the picture. Texture is very important in the visual arts.

In a photograph we can experience the surface of paper, plastics, stone, wood, and many other materials, and remember the feeling from the time when we have touched it. To be able to do this the lighting in the picture and the shadows are very important. Lack of detail communicates a smooth texture. In a painting clear and distinct brush strokes contribute to an impression of three-dimensional texture. Texture adds realism in a picture. It also adds an emotional and psychological effect. Many persons react in a positive way to soft and smooth objects, and they find sharp and rough objects repulsive.

Light

Light is essential to the appreciation of three-dimensional images like sculptures. Whether the light is coming from the left or

from the right, the top or the bottom, makes a crucial difference in the appearance of the forms. Soft light helps us appreciate subtle undulations. Strong light accentuates details on the surface. A *shadow* is an area where there is absence of light.

The word photography has its origin in Greek and means "writing with light." Drawers as well as painters and photographers make use of various lighting conditions, light, shadows, and darkness to create perceptions of volume in two-dimensional pictures. A person or an object depicted in hard or soft light will be perceived differently. The physicist defines light as visible radiant energy. Actually, light is invisible. We can see it only at its source and when reflected. Light has outer as well as inner orientation functions.

Outer orientation functions

Light will articulate our outer orientation with respect to space, texture, and time. Without shadows it may be hard to make out the basic contour of an object. Shadows define space. The attached shadow is on the actual object. It helps to reveal the basic form and dimensions of that object. The cast shadow is frequently observed as being independent of the object that caused it. Depending on the angle of the light source, the cast shadow may reveal the basic shape and location of the object that caused it. The surface appears to be curved when the light falls off gradually. A highly directional (hard) light produces fast fall-off. Thus, a curved surface is emphasised.

A highly diffused and non-directional (soft) light produces slow fall-out. Prominent cast shadows caused by hard light from a low angle emphasize texture. Soft light, on the other hand, de-emphasizes texture. Thus, both hard and soft light may be used

successfully for spatial and tactile orientation, for example, in portrait photography. In daylight the background is usually bright. The cast shadows are very pronounced and the fall-off is fast. In a night-time scene the background is dark. The lighting from various light sources is highly selective. Shadows are prominent. The human eye is attracted to bright areas. This can be used for emphasis and directing attention in a visual. Bright areas tend to be perceived in front of other picture elements, while dark areas tend to be perceived as receding.

Cast shadows. Here the pale light from the rising sun gives distinct cast shadows on the ground.

Inner orientation functions

As well as light can articulate space, texture, and time; it can also articulate inner orientation functions. In motion picture and TV production, light, especially combined with music and sound effects, can evoke a great variety of specific feelings and

emotions within us. Minor position changes of principal light sources may have drastic effects on our perception of mood and atmosphere. For example, a face lighted from below may appear brutal, dramatic, ghostly, mysterious, and unusual.

Composition

Composition is discussed here mainly within the individual picture, and not the composition of a page or a screen. We need to organize picture elements within an individual picture and find a balance according to aesthetic principles.

Organization

Usually a visual shall deal with only one concept, and only provide the information that is necessary for the audience to understand the content. The elements in a visual may be arranged in a pattern that is clear and easy for the reader to comprehend. Organization provides a pattern that facilitates learning. By organizing the graphic elements it is possible to direct the eye movements within the picture. Perceptually, we group things on the basis of similarity and distinguish between things on the basis of disparity. Certain stimuli, such as contour lines, unusual colours, or graphical symbols, are accentuated in perception while others, such as uniform areas, are not. Background colours, shades, frames, and typography, can be used to achieve unity. In this way the picture elements are viewed as a whole, as a unit. Horizontal and vertical lines are easily compared.

Organizing a message can make perception much easier and learning more efficient. The visual should have a moderate degree of complexity. Complexity without order produces con-

fusion, and order without complexity produces boredom. Differences in texture and grain may help organizing information.

To serve their function, schematic pictures must be well arranged. Since they cannot contain too many picture elements, it is better to divide the information into several different pictures than to allow one schematic picture to be overloaded. We should not use a schematic picture when a simple list will do. There must be sufficient distance between different elements in a picture, at least a few millimetres.

I it may be necessary to show several (= an undefined number) similar picture elements in one schematic picture, for example, several documents, several processes or several samples of particular hardware or software. To save space, the picture elements can be partly superimposed on one another, but it is wise to limit these elements to two or three at the most, to keep the schematic picture from being overloaded. To aid comprehension, a pair of picture elements that are connected to each other can constitute a symbol that means “several documents,” for example, or “several processes.”

To avoid misunderstandings, we should not use shadows behind picture elements to provide aesthetic spice or a false third dimension. If necessary, the number of picture elements can be shown as a digit on the actual symbol. The idea of “several” picture elements can also be expressed simply by giving the symbol a plural name.

We can place picture elements at different levels in a schematic picture. If we do however, it must be done in a logical, well-planned and consistent way to limit the risk of misinterpretation. We should avoid three-dimensional schematic pictures as they are often misunderstood.

Balance in pictures

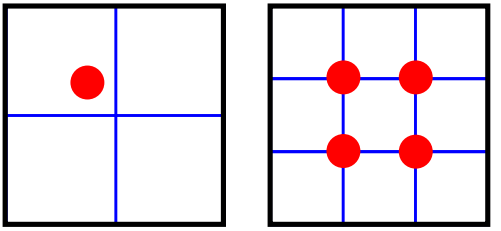
In nature balance is normal. A visual should usually display the best possible balance. Elements of the visual should fit together in an aesthetic and harmonious relationship in a manner that is interesting but not distracting. Man has an intuitive sense of balance. When a single element is too large or too small, too light or too dark, too prominent or too indistinct, the entire picture will suffer from this imbalance. Imbalance creates an uncomfortable feeling in the reader and should often be avoided. Imbalance, however, can be used to attract attention within a picture or within a material. Unexpected, irregular, and unstable design will attract attention. As soon as instability is introduced in a picture the result is a provocative visual expression. The eye will struggle in order to analyze the relationships and the balance within the picture.

Balance can be formal with total symmetry or informal. Formal balance is felt to be static and harmonious. Informal balance contributes to a feeling of dynamism. However, the mind needs stimulation and surprise. Contrast and imbalance can dramatize an image and attract attention. Several artists use a visual strategy, such as combinations of dark and bright, large and small, round and square, to sharpen meaning.

Centres of interest

Avoid dividing a visual in halves. The visual should only have a few centres of interest, preferably only one at or near its optical centre just above and to the left of its geometric centre or otherwise in the upper third of the visual. The centre of interest should be immediately apparent (McDougall and Hampton, 1990). Thus the visual has unity. The most important elements

of the visual may be emphasized to enhance perception. We may use lines of direction to guide attention to a centre of interest.



In the U.S., viewers tend to begin looking at a visual from the left side, particularly the upper left portion (41%). The dot is the optical centre. The illustration to the right shows the centres of interest according to "the rule of thirds".

Don't centre the centre of interest. According to the "rule of thirds" the centre of interest may be selected at any one of the four points where two equidistant vertical and two horizontal lines divide a picture in a total of nine parts. Don't centre a horizon. Place the horizon in he upper or lower third of the picture. Young children may choose to pay attention either to the whole picture or to specific parts of it. For children until about nine years of age it might be difficult to switch attention between a part and the whole.

Direction

Studies of eye movements and fixations have shown that various people look at the same picture in different ways. As previously noted the importance of eye movements can be summarized in five points:

- Only certain image elements attract our interest.

- The pattern for eye movements and fixations depends on what we wish to see or are told to see in a picture.
- Informative parts of a picture attract more fixations than less informative parts.
- Different kinds of pictures give rise to different kinds of fixations and intelligence and visual learning.
- There are a positive correlation between the number of fixations and intelligence and visual learning.

By organizing the graphic elements it is possible to direct the eye movements within the picture. Lines, shape, scale, perspective, position and orientation of objects are all essential parts in providing direction in a picture. Using lines with arrowheads is probably the easiest and most powerful way to show direction.

The information should be organized in such a way that the most important information is most prominent. We need to create visual focal points in order to highlight importance and to maintain interest in the visual. Diagonals are the most powerful directions in a visual. They may suggest a strong feeling of imbalance and motion. A left to right incline is associated with growth and prosperity, "uphill." Here the lower left part indicates inferiority, and the upper right indicate superiority and dominance. A left to right decline on the other hand is perceived as a decline, "downhill." Here the upper left part indicate superiority and dominance, and the lower right indicate inferiority. This may be very important in some schematic pictures. Also curved directions have elements of instability.

McDougall and Hampton (1990, p. 34) pointed out that subjects moving into a picture appear more dynamic than those moving out.

Pictorial perspectives

As discussed in *Information Design 2–Text Design* there are many kinds of perspectives. This section deals with various forms of *pictorial perspectives*. The concepts *verbal-linguistic perspectives* and *aural perspectives* are not discussed here, but mentioned in book 2.

The word perspective usually refers to a reproduction, on a plane surface, of a three-dimensional object, which conveys to the human eye the same impression of depth as that of the real object. It is a matter of creating an illusion of depth, for example on the surface of a paper.

With two eyes we naturally see in three dimensions. The illusion of depth and dimension is created when our brains interpret the slightly different views from our two eyes. We get a spatial awareness of our physical environment. We also have a tactile awareness in three dimensions of smaller objects. We have to distinguish between an *optical reality* and a *perceptual reality*. Optical reality is governed by geometry and is only visual. However, perceptual reality is governed by object constancy and combines what we already know about the subject with what we can feel, hear, see, smell, etcetera. Most pictorial perspectives are *spatial perspectives*. *Psychological perspectives* are visualisations of psychological and subjective concepts and values.

Considering the manner in which spatial perspectives are built up, they can be divided into three groups: *line-based positional perspectives, area-based positional perspectives,* and *other positional perspectives*. Of course, painters often use several different types of perspectives to enhance the effect of depth in a single picture. Line perspectives, aerial perspectives, colour perspectives, and tonal perspectives may well be used to

interact with each other and to create lifelike pictures. For schematic pictures that are meant to show three-dimensionality, it is usually more appropriate to only use one of the line-based positional perspectives.

Line-based positional perspectives

In a *line perspective* or *linear perspective* objects are conceived as being placed behind a picture plane onto which straight beams of light (so-called straight lines) are projected. All line perspectives are based on the idea that an object appears to grow larger in size as the distance between it and the observer decreases, and get smaller as the distance increases. A view along a road with identical lampposts or identical trees will produce the familiar convergence of lines. The lampposts and trees appear to be successively smaller. This phenomenon is sometimes called *diminishing perspective*.

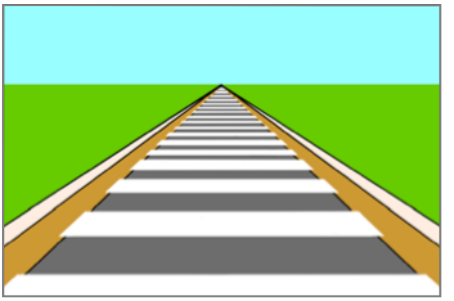
Distant objects appear to be smaller than objects that are close. When a car is approaching it seems to grow larger. However, we learn that the car will maintain its size. Regardless of distance there is constancy in the perception of the size of known objects. This is called size constancy.

In the western world the *position* in a picture of a known object, like a car or an ordinary person, with a known size will give us a depth cue. Regardless of distance there is constancy in the perception of the size of known objects (size constancy). The perception of distance is related to the perceived size, and the perception of size is reciprocally related to the perceived distance.

In visuals that are used for information and instruction we need to show scale and contrast. It is usually a good idea to include a person or a familiar object to supply the scale for judging the size of unfamiliar objects. The perceived size of an object is relative to the size of other objects. Thus, the size of an unfamiliar object is perceived as relative to the size of familiar objects.

Central perspective

A linear perspective uses the principle that parallel lines seem to converge or meet at a distant point. In a view of long straight roads and railway tracks the sides appear to meet at a vanishing point on the horizon even though they are parallel in reality. An artist represents linear perspective by moving all lines on the canvas toward a vanishing point on the *geometrical horizon* line. (The *true horizon* is the line dividing the sky from the ground. It is lower than the geometrical horizon since the surface of the Earth is curved. We can't see this difference when we are standing on the ground level. However, a person standing on a mountain can see further away.) The eye level of the observer determines the location of the geometrical horizon line. A central perspective is the graphic equivalent of optical reality.



Railway tracks appear to meet at a distant point on the horizon, the vanishing point.

One vanishing point

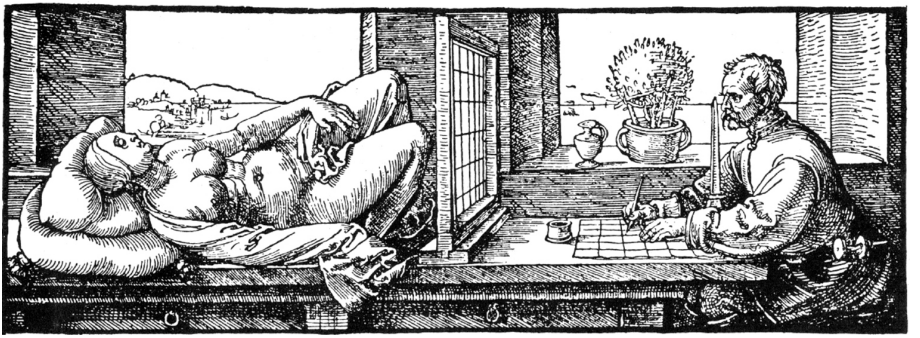
If all lines vanish in a single point, the picture is in a *one-point perspective*. This is also called *central perspective* and *Renaissance perspective*. One vanishing point is typically used in pictures of buildings directly facing the viewer, of hallways, railway tracks, and roads.

The central perspective is a rather recent perceptual acquisition, developed in the early Renaissance by artists who learned to see form and space in a new way. The laws of perspective had been known already to the Greeks and to the Romans but this knowledge had been lost. The Italian architect Filippo Brunelleschi (1377–1446) discovered the mathematical laws of perspective and he demonstrated the geometrical method of perspective about 1413. Brunelleschi worked out some of the fundamental principles, including the concept of the *vanishing point*.

The Italian multi-talented architect, classical scholar and explorer of the fine arts Leon Battista Alberti (1404–1472) regarded mathematics as the common ground of art and sciences. At this time pictorial art was regarded as a science that could be applied to explore the laws of nature. In his book *Della Pittura*

(De Pictura, On Painting) 1435/1436, Alberti relied on classical optics in determining perspective as a geometric instrument of artistic and architectural representations. He described Brunelleschi's mathematical construct of the central perspective (Toman, 1999, p. 448). Alberti showed how the rays of light, passing from the viewer's eye to the landscape, would strike the picture plane (the painting). He was able to calculate the apparent height of a distant object using two similar triangles.

The Italian painter Piero Della Francesca (1415–1492) further described central perspective for solid objects in any area of the picture plane. Della Francesca used illustrated figures to explain the mathematical concepts.



This woodcut (75 x 215 mm), the Perspective Machine *by Albrecht Dürer was published in the second edition of Course in the* Art of Measurement *(1538). Dürer made the original drawing around 1525.*

The first textbook to explain the basics of perspective was issued as early as 1492. Before then, several manuscripts had been written. Some woodcuts by Albrecht Dürer (1471–1528)

demonstrate a drawing table called a "Leonardo box," named after Leonardo da Vinci (1452–1519). This was a perspective tool using a frame with a square grid to achieve an accurate linear perspective of an object, when the artist worked on a surface with a similar grid. Using this method, the artist could be sure that all the lines drawn accurately represented the objects in correct central perspective positions.

At this time art was meant to represent in exact detail what could be viewed by a one-eyed person standing at a singular and exact location at a singular and exact moment in time. Science searched for theories that reduced human experience to its most basic forms, allowing for an abstraction into mathematical language.

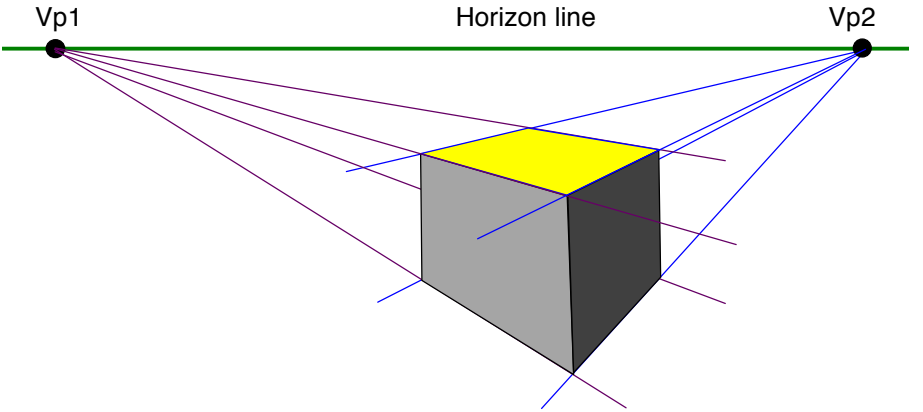
Soon most artists in Florence and in Italy used central perspective in their paintings. Gradually the Italian techniques became part of the training of artists across Europe. Some painters accomplished such accuracy that their works stand comparison with projection drawings, or even with photographs. In early Renaissance paintings, the floor is often made out of marble squares. These squares form a perfect linear perspective in the pictures. Some artists used to draw accurate landscapes using a large camera obscura. The artists actually worked inside the box, where they traced the upside-down image on a thin sheet of paper on the inner wall. Much later, light-sensitive material became the basis for photography.

Leonardo da Vinci's used central linear perspective to express the social importance of Christ in *The Last Supper*, one of most famous paintings. All of the diagonal lines in the picture converge on the face of Christ, at the vanishing point in the middle of the painting. However, Leonardo da Vinci was not

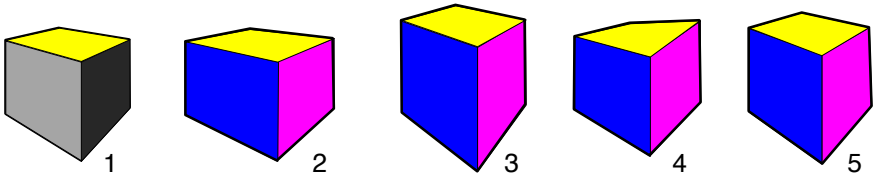
satisfied with the one-point perspective and he experimented with more views (McLean, 1999:106). The main disadvantage with central perspective is the exact rendering of an object from one specific situation with respect to conditions like distance, eye level, lighting, place and time. The object looks different when it is seen from all other places and in all other moments in time.

Two and three vanishing points

Lines that vanish in two directions to two different vanishing points produce a *two-point perspective*. This is also called *angular perspective* and *oblique perspective*. All linear perspectives have exact formulas with many and complicated geometrical and mathematical rules. The two-point perspective can be used to draw all objects.

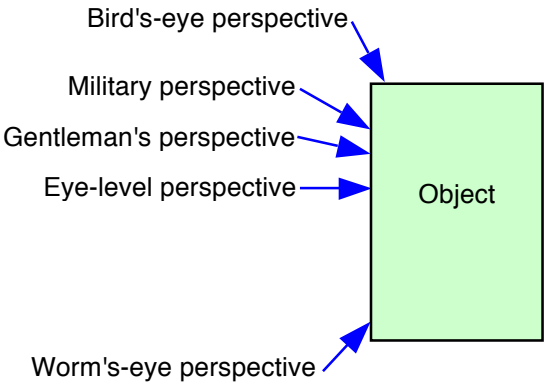


This cube is drawn in a two-point perspective, with two vanishing points (Vp1 and Vp2) on the geometrical horizon line.



In this illustration the first cube 1) is drawn in a correct two-point perspective. The other four cubes contain common errors in their perspectives. The second cube is too wide. The third cube is too tall. The fourth cube is out of convergence, and the fifth cube is out of proportion.

The *three-point perspective* is usually used in pictures of buildings seen from above or seen from below. In addition to the two regular vanishing points, there is also one below the ground or up in the sky. Each of the three vanishing points corresponds with one of the three axes of the scene.



We can distinguish between five different "level perspectives." Starting from the highest level these are called bird's-eye perspective, military perspective, gentleman's perspective, eye-level perspective, and worm's-eye perspective.

Dondis (1973) pointed out that perspective dominates in photography. Today, any standard camera with ordinary lenses provides us with linear perspective pictures. The camera lens has some of the perspectives of the eye, and simulation of dimension is one of its prime abilities. Some photographers use linear perspective and its vanishing point or points to create dynamic compositions. By association, diagonal lines of all kinds contain a suggestion of depth.

The field of the camera lens is changeable. What we can see and record is determined by the focal length of the lens. The normal lens has nowhere near the range of field of the human eye, but from a depth point of view, what it records is close to the perspective of the eye. Telephoto and wide-angle lenses can distort the representation of reality. A telephoto lens will narrow, and a wide-angle lens will broaden the field. Regardless of the lens used during photography, the actual light sensitive film in the camera is the same. Thus, only a normal lens provides a "good" representation of an object on the film. At the same distance all other lenses give some distortions.

Bird's-eye perspective

In the *bird's-eye perspective, or bird's-eye view,* an object is viewed from a high position. We may be looking down from a vantage point in a high building, on a mountain, or in an airplane. Bird's eye views have existed since classical times. In art, film, photography and video a person seen from this perspective look small, unimportant, and weak. Too high view of a person shows little convergence. The perspective is often used for blueprints, floor plans and maps.

Here are people standing in the lobby of a hotel.

Some satellite photos and computer programs offer the viewer the opportunity to "fly over" and observe parts of cities and landscapes. This perspective is often used when there are three vanishing points, one below the ground or in the sky, one on the left, and one on the right.

Sometimes the terms *aerial view* and *aerial viewpoint* are used for bird's-eye perspectives. The term *aerial view* can refer to any view from a great height, even at a wide angle.

Eye-level perspective

Objects are usually viewed straight from the front and when at the same level as the viewer. This “normal” way of viewing could be said to represent the *eye-level perspective* or *normal perspective*. Compared with a normal camera lens, the narrow field from the telephoto lens makes the representation of an object broader on the film. The wide field provided by a wide-angle lens makes the representation of an object narrow on the film. Wide-angle lenses have a propensity to enhance linear perspective, while telephoto lenses tend to flatten the perspective. Objects are usually viewed straight from the front and at the same level as the viewer. This “normal picture angle” and the normal way of viewing is the least obtrusive angle.

The *gentleman's perspective* is higher than the eye-level perspective but lower than the *military perspective*. Several

historical paintings of troops and battles show a *military perspective*. Higher than the eye-level perspective, this was perfect to see the different groups of soldiers on the battlefield. In computer and video games, an *overhead view* of a situation places the vantage point only a few feet above human height. The bird's-eye perspective is the opposite of a worm's-eye perspective.

Worm's-eye perspective

In the *worm's-eye perspective, worm's-eye view,* or *frog perspective*, an object is viewed from below (at an oblique angle). This perspective is often used in propaganda. The viewer has to look up to something. In art, film, photography and video a person seen from this perspective look big, important, mighty, powerful, strong and tall. However, a too low view of a person fails to read clearly. This perspective is often used when there are three vanishing points, one on top, one on the left, and one on the right. This is the opposite of a bird's-eye perspective.

Time perspective

A “time-line” is a simple one-dimensional scale with markings for important events. This is often used in graphics and schematic pictures to visualize the relationships between different historical events. Using a time-line makes it easier for the viewer to see the time perspective.

Forced perspective

A *forced perspective* is a form of optical illusion. Forced perspective is used in architecture, film, photography and video to manipulate human visual perception. It is used to make an object appear to be larger or smaller, to be closer or farther away

than it actually is. Producers use scaled objects and manipulate the correlation between them, the camera or viewer, and the vantage point. In the picture a large distant building or a group of dinosaurs in the background may in fact only be very small miniature models that are hold close to the camera. Then the building and the dinosaurs may look monstrously tall in the final pictures.

Forced perspective was often used in movie production in the 1950s and 1960s. These productions required complicated lighting since the intensity of light rapidly decreases when the distance to the objects increase. The foreground object as well as the background must be sharp. Modern digital processes may often be employed today.

Forced perspective is often used in architecture of entertainment theme parks, like Disneyland. Here different buildings and other structures often need to seem larger than they are in reality.

Curvilinear perspectives

The *four-point perspective*, or *infinite-point perspective*, uses curving perspective lines to approximate the image on the curved retina in the bottom of the human eye. It is the curvilinear variant of a two-point perspective. A four-point perspective image becomes a panorama that can go to a 360 degree view and beyond. When also a vertical line is used as a horizon line it is possible to see both a worms eye view and a birds eye view at the same time (Wikipedia, 2013a).

The *five-point perspective, or fisheye perspective* has four vanishing points placed in a circle and one in the centre. This is the curvilinear equivalent of one point perspective. Fisheye

lenses are ultra wide-angle lenses that produce strong visual distortions. These lenses are used to create wide panoramic or hemispherical images.

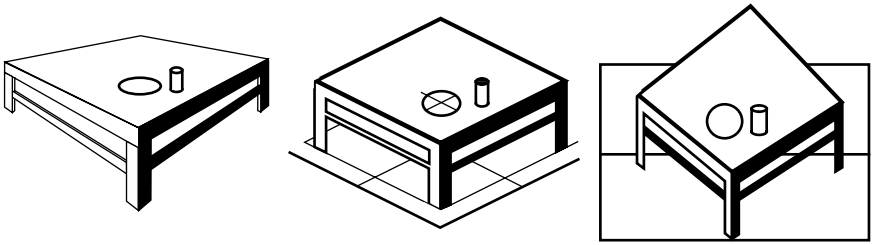
Parallel perspective

When the distance is endless parallel lines of an object are parallel in the picture too. This is called *parallel perspective*. In the western cultural sphere, we are used to seeing visuals with one- and two-point perspectives. Perspective drawing offers possibilities to reproduce depth, but it is always limited to showing objects from just one certain point. In several cultures it is better to use *orthographic views*. An orthographic drawing does not show an object in perspective, but in "scale." Objects are represented as they are remembered. Mechanical orthographic drawings show proportions accurately with a parallel projection. Parallel lines of an object are parallel in the picture too. This results in three-dimensional pictures with distorted diagonals.

When orthographic drawing is traditional in a culture, it is usually drawn freehand, and accuracy is not so important. In some places, only man-made objects and buildings can be drawn orthograpically; natural things, including people may not be drawn this way. Zimmer and Zimmer (1978) called orthographic views or orthographic projections non-perspective, but they are sometimes called *parallel perspectives* resulting in *paraline pictures*. Brouwer (1995) noted that the concept of perspective in a picture is usually not understood in rural Africa.

In parallel perspective a plan shows a view locking down on an object, a section is an image that describes the object as if it

is sliced, and an elevation is a view looking from any angle describing relationships of verticals and horizontals. Parallel perspective combined with a viewpoint from above is common in traditional Chinese painting. Often foliage is used to crop the parallel lines before they extend far enough to cause a building to appear warped.



In the western cultural sphere, we are used to seeing visuals with central perspective, as in the drawing of a table (left). In some cultures it is better to use orthographic views that do not show an object in perspective. The mechanical orthographic drawing of a table (middle) shows proportions exactly. A freehand orthographic drawing, to the right, is not so exact. In parallel perspective (right) parallel lines of an object are parallel in the picture too (adopted from Zimmer & Zimmer, 1978; pages 58–59).

Reversed line perspective

In a *reversed line perspective* the foreground seems to be smaller than the background. The straight lines converge in the direction of the viewer. This perspective is frequent in Japanese and Chinese art, which seeks to draw the viewer into the picture to take an active part in the events depicted. In early Asian art there are no shadows. It is conceivable that a reversed line per-

spective can be either a reversed parallel perspective or a reversed central perspective.

Area-based positional perspectives

As noted earlier central perspective has one or more vanishing points. A perspective with no vanishing points, a *zero-point perspective*, occurs when the viewer is observing a non-rectilinear scene like a natural scene. In painting and photography the depth of a picture can be visualised in several ways and not only through a linear perspective.

According to Freeman (1988) a heightened sense of depth through strong perspective tends to improve the realism in a photograph. It makes more of the representational qualities of the subject, and less of the graphic structure. Photographs often have well-defined foregrounds and backgrounds, and parts in between. Depth of field is how much of a picture from near to far is in sharp focus. In photography the depth of field is influenced by the distance to the object, the focal length and by the camera aperture. The depth of field can vary from several meters to a few decimetres. By making the foreground sharp and the background blurred, the interest of the viewer is directed to the foreground, and vice versa.

The group area-based positional perspectives include *aerial perspective, colour perspective, tonal perspective, overlapping perspective*, and *shadow perspective*.

Aerial perspective

In a picture of an open landscape, without a natural and obvious line perspective, *aerial* and *colour perspectives* create an impression of depth. The air and atmosphere is never absolutely

clear and clean but rather filled with a grey or greyish blue haze, moisture, and dust. This acts like a filter and makes distant objects seem obscure and wrapped in mist and they may be partly hidden. Distant objects are lighter than nearer objects. Their contrasts with the backgrounds are reduced. Colour saturation is reduced and shift towards the background colour, usually blue. At sunrise or sunset distant colours may shift towards red. When the distance to an object increases, the contrast decreases. As a consequence, objects viewed from a long distance are indistinct and pale. This phenomenon is called *aerial perspective,* or *atmospheric perspective*.

This picture demonstrates a combined aerial and colour perspective in the afternoon. Colour saturation is reduced and shift towards the background colour.

Aerial perspective was commonly used in paintings from the Netherlands in the 15th Century. Lenardo da Vinci used aerial perspective in many of his paintings such as the *Mona Lisa*.

An artist draws objects nearest to the observer in sharp, heavy lines and bright colours. Sections of a painting that are intentionally made indistinct, without sharp outlines and in neutral colours, will appear as being located far away. They fade away into the distance. In photography the effect of aerial perspective appears strongly in backlighting.

Colour perspective

In a *colour perspective* colours and hues gradually change from being clear in the picture's foreground into being blurred in its background. Warm-coloured objects appear closer to the viewer than cool-coloured objects. A red or orange object against a green or blue background will have a sense of depth.

The perception of size is influenced by colour and grey scale. Open and light forms are perceived as being larger than closed and darker forms of the same shape. The perception of size is very much influenced by contextual variables. Large cannot exist without small.

Tonal perspective

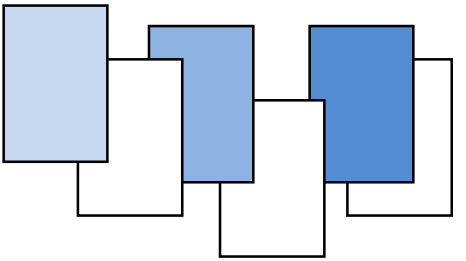
Light tones appear to advance and dark tones appear to recede. A light object against a dark background will normally stand forward, with a strong sense of depth. This phenomenon is called *tonal perspective*.

In practice, it is difficult to distinguish between aerial perspective, colour perspective and tonal perspective. They are so closely interrelated that they may be regarded as different aspects of the same thing. When we take photographs of objects at a long distance, both aerial and colour perspectives may be intensified by the use of special lenses and filters.

Overlapping perspective

When certain objects are placed in front of other objects this will enhance the impression of depth in a picture. The overlapping perspective was quite common in European mediaeval art. The *overlapping perspective, cropping perspective*, or *playing-card perspective* should always be used with cautiousness–in a

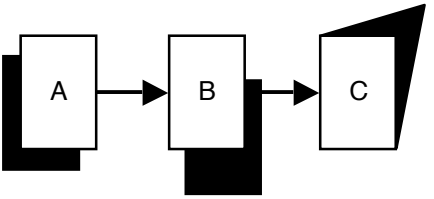
correct, logical, well thought-out and consistent manner. Otherwise, the risk of misinterpretation is obvious.

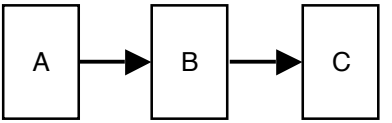


We easily see this pattern as objects partially occluded by one another.

Shadow perspective

In a *shadow perspective* projected shadows, or drop shadows, are sharply accentuated as a means of displaying the location of different objects and their spatial relations to each other. Even some of the old rock paintings in caves reveal attempts at producing an impression of depth, by the suggestion of simple cast shadows. In schematic pictures and in news graphics a cast shadow behind individual picture elements, or behind two edges of the complete picture, may create feelings of three dimensions and depth. If this is done correctly, the picture seems to be floating above the page.





Avoid all kinds of drop shadows behind picture elements in schematic pictures! Drop shadows will impair the reading of the actual data and information in the pictures.

However, cast shadows may create confusion and they may actually impair legibility and communication. In particular, it is confusing when the shadows in a picture are of different sizes, implying three-dimensionality and a perspective that neither exist nor need to exist. Sometimes shadows may fall in different directions in the same picture.

Other positional perspectives

The remaining positional perspectives comprise two types. These are *geometrical perspective,* and *multi-view perspective*.

Geometrical perspective

The placement of objects within a picture is important in *geometrical perspective*. This is common among traditional Japanese and Mayan artwork. Here, objects close to the viewer are shown in the lower part of the picture. Objects that are further away from the viewer are shown in the image above the near objects in the lower part. The most important figures are often shown as the highest in a composition. Objects further away may be placed on a vertical line, as steps on a ladder. This is sometimes called *vertical perspective*. Geometrical perspective is quite common in children's drawings.

Multi-view-perspective

In *multi-view perspectives* different views appear at the same time in a picture. The pictures of young children, like many of the paintings from ancient Egypt, India, and pre-Renaissance European art depict objects independently from their surroundings. The pictures show objects as they are known to be rather than as they are seen to be. Objects and figures are shown in multi-view perspectives from all the different views that best

present their most characteristic features. In many Egyptian paintings the head and legs of a person are shown in profile, while the eye and torso are shown frontally. This system produces a sense that objects and surroundings have been compressed within a shallow space.

Up to the time when Modernism started to question its laws of construction, the central perspective was considered the only correct type of perspective in Western art. At the end of the 19th century Paul Cézanne flattened the conventional Renaissance central perspective. Inspired by Pablo Picasso, the cubists broke off completely with the traditional conception of space, and modern art became totally liberated from the time-honoured laws of perspective. Today modern art, oriental art, and illustrations in children's books often use multi-perspectives or multi-view perspectives.

Psychological perspectives

The second main group of pictorial perspectives are *psychological perspectives*. These perspectives are visualisations of psychological and subjective sets of values and illusionistic effects. This group includes *imaginary perspective*, *simultaneous perspective* and *value perspective*.

Imaginary perspective

During the Baroque era, a special perspective was used in European architecture and pictorial art for the purpose of creating illusionistic effects, the *imaginary perspective*. The artists made individual interpretations of what they saw, and represented these ideas in their paintings. When we convey information in information design and instruction design, the purpose

is the opposite: to present facts as clear and unambiguous as possible. Modern examples of imaginary perspective are found in pictures created by means of spherical lenses.

Simultaneous perspective

In the European medieval *simultaneous perspective,* time is a spatial dimension in paintings. Several manifestations of the same character or person may be seen in one picture. The allegories, icons, and symbols that are used determine to a large degree the interpretation of medieval images. Several manuals with directions for understanding visual arts have been published. One very important example is the book *Iconologia*, written by the Italian art historian and scholar Cesare Ripa (c. 1560–c. 1645). He worked as a cook and butler for the Cardianal Anton Maria Salviati. In his free time he studied the symbolism in Egyptian, Greek and Roman emblem books (Wikipedia, 2013b). The *Iconologia* is a didactic illustrated book with a collection of erudite allegories.

The *Iconologia* was first published in Rome 1593, and later published in another eight Italian editions, and eight editions in other languages. Ripa was knighted for the success of the book. For more than three hundred years experts in art history all over Europe used *Iconologia* as their prime source of knowledge when they discussed description, identification, interpretation of the content of classical art. Art historians have learned, and know the language of art. However this is, and was, not true for people in general. The general public lack these necessary frames of references.

Value perspective

In art of more ancient date, and even in primitive art, there are many examples of perspective based on *meaning, contents*, and *value*. The significance, rank, status, or value of depicted objects is evident from the object's size in the picture. Geometrical and mathematical laws are set aside. In Egyptian traditional art, the gods are larger than Pharaoh, who in turn is considerably larger than all his subjects. In several Middle East countries today, the most important person in a group picture is larger in size than the other, less important people. Leaders who happen to be short appear to be "big" leaders since they are the largest in the group. This is also a gender issue. Lester (1995) noted that (p. 49):

> In a picture of a couple, the man's dominance over the woman often is signified by the man being nearer and larger in the frame with his hand resting on or arm wrapped around the woman's shoulder. Over the past two decades, feminist movement has made advertisers and others more sensitive to nonverbal, negative stereotypes such as these.

This kind of perspective can be called *value perspective* or *social perspective*.

Picture editing

McDougall and Hampton (1990, p. ix) explained that picture editing does not deal in absolutes. Taste and judgement are essential because so many variables can influence editing decisions. When we find "good" pictures we can't take for granted that we can use them as they are. There is usually a need for cropping and/or changing the scale of selected pictures. Some-

times it is also possible to manipulate the picture by changing the projection, expanding or compressing the image, changing, adding, deleting, moving, or turning specific picture elements in various ways. However, in most of these cases we need to get permission from the copyright holder/s to do any manipulation with the pictures. McDougall and Hampton (1990, p.2) provided the following seven questions as an approach to picture editing in visual communication.

1. Is the picture informative; is it interesting?
2. Do camera and darkroom or electronic techniques reinforce the message?
3. What words are needed to strengthen the message?
4. Will cropping improve the content or composition?
5. What is the minimum reproduction size for readability?
6. Does one picture say enough or would two or more be better?
7. How will layout best convey the message?

Wileman (1993) and a number of other authors have described different methods for the editing of visuals to change their importance and impact. Some important changes that can be made to a visual prior to publication should be mentioned. For example, a picture editor may elect to crop or expand the original picture. Parts of the picture can be deleted, added, altered, moved or changed in shape. The picture can also be enlarged or reduced. A colour can be changed, removed or added. The picture's expressiveness can be altered by the choice of repro method etc.

Selection of pictures

Different people perceive and describe any given event in different ways. Photographers, journalists, editors and graphic designers may all have different priorities and they may make separate selections. This means that readers and viewers have completely different opportunities to interpret what has actually happened in connection with a given event.

Every published picture has been selected, not only once but usually several times. First the picture creator, the photographer, and/or the artist makes a selection of the subject matter. The photographer makes the initial decision as to how much or how little of a situation will be on the film. In any given situation a lot of different pictures may be produced. Then the editor, art director, and/or the designer make a selection among various pictures in a collection or in an picture archive. In instructional materials a picture should never be used just because it is pretty. Every picture should have some information to convey–if it doesn't, it should be left out.

There is often a clear difference between the intended and the perceived message (Pettersson, 1985). One way to decrease this gap is to supply all pictures with interesting and explaining captions, supporting the intended interpretations (Melin & Pettersson, 1991). When too many pictures of different types are used in one single message, some of the pictures may be ignored. There will also be less space for the text. Unfortunately, often archive pictures are used in a way not intended. Sometimes the same pictures appear in several different contexts, which may confuse the readers.

As noted before pictures may even have a negative effect. Some illustrations (often without captions) in contemporary

textbooks appear to serve no useful purpose whatever. Some picture editors admit that some of the pictures they put into textbooks are only there to "stimulate" the reader, to have "a life of their own," or merely to provide a "breathing space" within the text. Such uses seem very dubious. In fact some publishers admit that the two main reasons to use pictures in their books are to 1) attract buyers and 2) increase the prices.

Interviews with editors, art directors, and designers from major Swedish publishing houses showed that they, in the selection of visuals for reference books and textbooks, often ask themselves questions such as the following (Pettersson 1989, p. 145):

- Does the picture depict the right thing?
- Is the presentation of the subject satisfactory?
- Is the picture technically acceptable?
- Is the picture aesthetically satisfactory?
- Is the picture "flexible," i.e., will it work with different formats?
- Will the picture fit into a given area?
- Will the picture fit in with the other pictures on the same page?

In practice, many editors, art directors, and designers find that 1) procurement time, 2) availability, and 3) image clarity are the most important considerations in making their subjective choices among possible visuals. Evans, Watson and Willows (1987) interviewed editors, art directors, and designers from nine major Canadian publishing houses. They concluded (p. 90): "Our interviews confirm Dwyer's (1972) summary that the selection and inclusion of illustrations in textbooks appear to be based on

"subjective feelings of the designer about what is best, the accessibility of raw information, the availability of materials, the cost, the attractiveness of the finished product, and the availability of a ready market" (p. 16)."

Marsh (1983:101) provided the following eight guidelines for selecting a visual channel for a message:

- When messages are complex.
- When referability is important.
- When messages are long.
- When environment is noisy.
- When arrangement is complicated.
- When precise spatial discrimination is important.
- When simultaneous presentation is desired.
- When more dimensions are required.

McDougall and Hampton (1990, p.3) recommended three pragmatic tests for judging photo merit in the context of journalism. The tests concern message, aesthetics, and technique.

1. Messsage
   - Does the photo make a clear statement?
   - Does the photo meet the ethical standards of responsible journalism?
   - Does the photo invade the privacy of its subjects or libel them?
2. Aesthetics
   - Is the photo's composition well-organized and aesthetically appealing?
   - Does the composition facilitate the message?
3. Technique

- Do the camera and darkroom techniques enhance the photo's message?
- Is the photo of press reproduction quality?

Preference for a particular visual format does not necessarily result in increased learning. Yet, in the absence of more substantial data, information based on student preference has a meaningful role to play in affecting learning from information materials and instructional texts. All other things being equal, we should provide formats that are preferred by the viewer, thus making the text more attractive, and hopefully more motivating. Thus selection of artistic style for visual materials should not be an arbitrary decision, but always a conscious one.

Although full-colour photographs increase the costs of trade books Ramsey (1989) suggested that publishers should increase the number of such books available for primary audiences. Today, however, there are only few informational books for children which meat these criteria. It is actually quite common that various kinds of abstract illustrations are used in textbooks.

Visuals for information should be attractive but "unambiguous," i.e. not too "artistic" and therefore ambiguous. Visuals that are attractive and that people like also have greater impact. To increase interest in a material it might be a good idea to use a blend of several kinds of visual types such as diagrams, drawings, and photos. Generally speaking it is not possible to rank the different types of visuals. Often the type of visual that should be used must be determined in each individual case with a view to various demands on the picture and the prevailing budget framework. It is often easier to control the production of

a drawing than the production of a photograph. So a drawing may be the only realistic alternative in many situations.

However, since pictures illustrated in more abstract styles, such as cartoon and expressionistic, might generate more imagination such pictures might be used as stimuli for creative writing assignments. It is not enough to select good visuals and make sure that all the pictures have relevant captions. To really help the readers to improve their use of visuals in textbooks, AV-material, and other teaching aids, we should give the teachers careful guidance, for instance in a teachers guide. The guide should:

- Show the purpose of each individual picture.
- Complete the caption and tell what each picture shows
- Give different examples of how every picture can be used in the education, what is important to discuss, which tasks can be assigned in connection with the picture, and so on.
- If needed provide complementary facts, for instance explain how the picture has been produced.
- Account for name of photographer, artist or other picture creator.

Effective visuals for information should create an experience for the reader. The reader must:

- See or rather "discover" the picture.
- Pay attention to the picture.
- Read the picture in an active and selective way.
- Process the information mentally.

Winn (1993) concluded that pictures play many roles in instruction. It is therefore necessary to know precisely what a picture's

function is intended to be before it is designed. Cognitive and decorative functions should never be confused or mixed (Pettersson, 1989). It should be remembered that pictures might have a negative effect. Illustrations move from being engaging motivators to engaging distracters at some point (Evans, Watson and Willows, 1987). When too many pictures are used, readers may ignore many of them. Massoumian (1989, p. 19) noted, "Haphazard use of visuals may lead to minimal or no instructional gain and gradual loss of effectiveness as an instructional tool."

Visuals cost money, often quite a lot of money. But in many situations a "good" picture need not cost more than a "bad" picture! Spending a lot of time on the visualization process and on sketches (usually a less expensive process than the cost of originals, "masters," and printing runs) may therefore be worthwhile. Usually several sketches or outlines make a basis for decisions necessary in the production of the final drawings.

A selected photo often needs cropping. By cropping, distracting and/or uninteresting parts of the image will be eliminated. Pictures should always be adjusted to fit into their final context. Image framing makes a clear distinction between image and background. Fading is used to make the image gradually appear on the page. Layout is the integration of text and images, i.e., on an opening in a book. Captions give the reader necessary guidance in understanding the image content.

Cropping

An original picture can often be improved by removal of irrelevant or distracting elements. Usually pictures can be cropped a little bit from all sides. In practice the photographer always per-

forms some "initial cropping" while taking the actual photograph. When composing or taking a photograph, the photographer sets the boundaries or "frame" of the picture. The same is also true for the artist who makes a "mental cropping" before s/he starts the actual drawing process.

The picture editor should not manipulate the meaning of the photo by cropping off people so that the relationships among those remaining in the picture are changed. This happens sometimes in newspapers and also in books. McDougall and Hampton (1990, p. 94) provided an example that may be the most notorious example of manipulating our perceptions of truth by cropping. The USA Senator Joseph McCarthy feared that communists were taking over America. He accused people with power, including the government, large American institutions, and the United States Army. During the "Army-McCarthy Hearings" in 1954 McCarthy used a *cropped photo* in an attempt to discredit Robert Ten Broeck Stevens, who was the "Secretary of the Army." The original print showed four people standing by a military plane. McCarthy had the two men at the left cropped out to make it look as if Stevens were friendly with a former McCarthy aide. Attorney Joseph Nye Welsh's exposure of the fraud led to McCarthy's ruin.

To find the most interesting part of a visual we can use two setsquares cut out of white cardboard. Move them around until you find the best cropping possible. Mark the desired cropping on an overlay or on a plain copy of the picture. Be very careful with the original print. The actual cropping is usually done in a scanner at the print shop. In desktop publishing systems you can make the cropping of an image electronically. You will then have to define the area that you want to keep and remove the

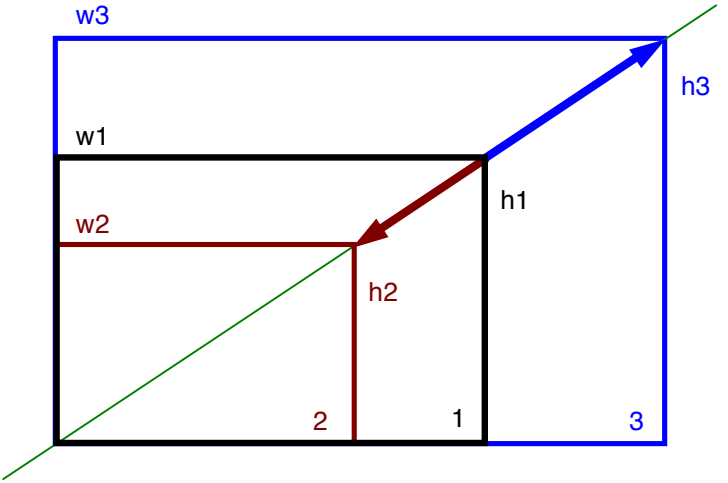
other parts or make a copy of the defined area. A complicated picture can be cropped and divided into two or more parts, each supplied with their individual captions. Sometimes images can be cropped to non-rectangular shapes like ovals or soft round shapes. Cropping and changing of scale are the most common methods used in picture editing.

The ratio of face to body, the *face-ism ratio*, influences the way we perceive a person in an image (Lidwell et al., 2010, p. 88). When the face takes up most of the image we focus on the person's intellectual and personality attributes. When the body takes up most of the image we focus on the person's physical and sensual attributes.

Changing scale

Pictures should always be adjusted to fit into their final context. An image may be scaled up or down. There is an optimum size for each visual. The content remains the same but the chosen scale can influence our perception of it.

A picture can be enlarged or reduced in the same proportions as the original if the new dimensions meet at the diagonal of the original (see the illustration on next page). This is called the "diagonal line method of scaling." Draw a diagonal on an overlay on top of the image. Decide on the desired width of the scaled version, and then measure the height. Or do it the other way around. There is an easy "algebraic proportion equation" which we can use for scaling. The original width is to the original height as the reproduction width is to the reproduction height ($w1/h1 = w2/h2$).



An image 1) can be reduced 2) or it can be enlarged (3). When scaling w1/h1 = w2/h2 = w3/h3.

The "Brandt Scaleograph" is a mechanical aid that uses semi-transparent "Ls" that slide on a metal rod representing the diagonal of a rectangle. The "Proportion wheel scale" has two wheels. An outer wheel represents the reproduction size and an inner wheel represents the original size.

The size of the visual should be large enough for the image to be legible. If the plane of projection is changed the relations between various parts in the picture will be influenced. Usually drawings are produced in a larger size than the intended size in the finished product. When scaling down, lines get thinner, tighter, sharper, and more distinct. Drawings look better because lines appear to be more confident. However, small details may disappear. Scaling up has the opposite effect. Lines tend to dissolve and small mistakes become more obvious.

A bit-mapped image, created and stored in a computer, may be scaled. However, no new information is added when the image is enlarged and important information is lost when the image is reduced. Thus, it is normally best to create bit-mapped images in the correct sizes. Another possibility is to create a bit-mapped image in a large size, scale it down with a repro-camera or with a copying machine and then paste it as an original. Object oriented objects may; however, be scaled without loss of quality. Sometimes it might be a good idea to enlarge interesting parts of a picture. Several consecutive enlargements of a specific part will help the reader to understand the detailed structure of an object.

Text in pictures

Texts within pictures should usually be printed in Helvetica nine or ten point, normal style, and should be as concise as possible. As a rule, texts within a picture element should be centred. Make sure that words or whole texts do not spill over different picture elements, as this will make both the picture and the text difficult to read. When a heading is needed it may be set in nine point bold Helvetica. Avoid using several lines of text inside a symbol. It is difficult to keep distances consistent inside different symbols, and it is easier to read one short line than several lines. Sometimes it may be a good idea to consider labelling graphics in multiple languages.

Visualization

Since the Neolithic period (approximately 10,000–2,000 BC) people have communicated not only through gestures and sounds, but also by means of visual language (de Jong, 2010, p.

7). Any technique for creating animations, diagrams, and images to communicate a message can be labelled *visualization*. Since the invention of central perspective in the Renaissance period the invention of computer graphics may be the most important development in visualization.

Analysis and presentation of data is an indispensable part of all applied research and problem solving in industry, and also in many branches of science. One of the most fundamental approaches to analysis and presentation of data is *visualization of abstract data*. Usually the goal of visualization is to present abstract data in clear images in order to improve understanding of the content.

Already in 1765 the British scientist Joseph Priestley designed his diagram *A Chart of Biography* with *timelines* for important individuals. In 1786 the Scottish engineer and political economist William Playfair developed the *line graph* and the *bar chart*, followed by the *pie chart* (1801) and the *circle graph* (1801) to represent economic data. (See the book *Information Design 6–Predecessors & Pioneers*.)

Effective visuals

Perception is always organized (see section *Perception* in the book *Cognition*). We perceptually construct relationships, groupings, objects, events, words and people. We see dots, lines, areas, light, dark etc. in an organized way. One of the simplest perceptual organizations is that of "figure and background." Some elements in a visual are selected as the figure. The remaining elements constitute the background. Our ability to distinguish the boundaries of an image is usually very high. "Good

figures," i.e. in the sense of simplicity, regularity and stability, are closed and exhibit a continuous contour.

A given contour can belong only to one of the two areas it encloses and shapes. The contour shapes will be perceived as a figure. Necker's cube can be seen in either of two configurations. Reversible figures lack sufficient cues as to which side of a contour is figure and which is the background. This is often used to create illusions. Many have seen a reversible figure that is perceived as a vase or as two heads facing each other.

Highly developed perceptual abilities are needed to detect the bounds of a single image within a complex structure. Small children may find it difficult to switch attention from parts to the whole and back again. When lines overlap or compete, emerging figures have good continuation. The most symmetrical and simple figures constructed will be perceived.

This is an example of camouflage. Two differently painted small models of tanks are photographed in similar positions in a woodland model at FOA, the Swedish National Defence Research Institute.

There are many examples of *camouflage* among animals. However camouflage is also used by the military. The objective in military camouflage is to hide positions, troops, weapons, and vehicles from the eye of the enemy. As a result of considerable research military camouflage on land, at sea and in the air developed rapidly in the 20th century. Thus camouflage is the opposite of information design, it is *disinformation design*.

Tufte (1997, p. 64) discussed *magic*, the production of entertaining illusions. He noted that magic is to engage in disinformation design. So here inventory of conjuring methods provides evidence about what not to do in information design. When visuals are produced for informative purposes, it is always a good idea to start by trying to "visualize" the information to be conveyed. "Visualizing" a message means that you attempt to materialize it in an effective synthesis of words and pictures.

Visualization is always a composite task, never a single act on its own, and requires the collaboration of several different parties. Dondis (1973) discussed the anatomy of a visual message. We express and receive visual messages on three levels: 1) representationally, 2) symbolically, and 3) abstractly. Representational forms of illustrations are actual photographs of things. In symbolical forms pictures show one thing and connote another. In abstract forms illustrations provide minimal visual information on the phenomenon illustrated.

Visuals that are attractive and that people like also have greater impact. To increase interest in a material it might be a good idea to use a blend of several kinds of visual types such as diagrams, drawings, photos etc. Generally speaking it is not possible to rank the different types of visuals. Often the type of visual that should be used must be determined in each individ-

ual case with a view to various demands on the picture and the prevailing budget framework. It is often easier to control the production of a drawing than the production of a photograph. So a drawing may be the only realistic alternative in many instances. However, since pictures illustrated in more abstract styles, such as cartoon and expressionistic, might generate more imagination such pictures might be used as stimuli for creative writing assignments.

It can be concluded that effective visuals for information should create an experience for the reader. The reader must: (a) See or rather "discover" the picture, (b) pay attention to the picture, and (c) actually read the picture in an active and selective way.

Visualization of data

Modern study of visualization originated in *computer graphics,* and has further evolved from studies in business presentations, computer science, human-computer interaction, interface design, psychology, and visual design. However, at the beginning the lack of computer power limited the usefulness of visualization. Now practical applications effectively analyse and present data in ways that facilitate human cognition and interaction. Now analysts can detect, see, and study expected patterns and also discover the unexpected from conflicting, dynamic, incomplete, and massive loads of data. Previously this was often impossible. Visualization involves research in computer graphics, high performance computing, image processing, and other areas.

During the last decades there has been a rapid and ever-expanding development of applications for visualization in

many different areas. Lengler and Eppler (2007) used the periodic table of chemical elements as a visual metaphor to classify 100 different methods of visualization. In their "periodic table of visualization methods for management" these methods are categorized into six groups: 1) Data visualization. 2) Information visualization. 3) Concept visualization. 4) Metaphor visualization. 5) Strategy visualization. 6) Compound visualization.

In the illustration of the system each group has the same background colour. The numbers of the methods show the increasing complexity between and within groups. All different branches of modern visualization can contribute to information design with methods and results.

Biovisualization

During the Renaissance professor Andreas Vesalius revolutionized the study of biology and the practice of medicine. His illustrated textbook *De humani corporis fabrica,* first published in 1543, represented top-level research in the field of anatomy. At that time, no distinction was made between art and science. Vesalius' careful verbal and visual descriptions combine the unknown with the well known. This is still characteristic for bio visualization. (See the book *Information Design 6–Predecessors & Pioneers.*)

Biovisualization is visualization of biological systems. Modern techniques and tools offer effective means for analyzing data from complicated biological processes and systems, healthcare, and medicine. *Bioinformatics* use visualization engines for interpreting lab data and also for training purposes. Visual analytics combine the strength of automatic methods with the expert knowledge of the analysts.

Data visualization

An early example of data visualization is the *dot map* used by the English physician John Snow in 1855 to visualise the cholera outbreak in Broad Street, London. The British nurse and statistician *Florence Nightingale* tended to wounded soldiers during the Crimean War. She developed and made extensive use of *polar area diagrams*, a special form of pie chart, in her reports 1858 on medical care. Civil servants and Members of Parliament were unlikely to understand traditional statistical reports. After his retirement the French civil engineer *Charles-Joseph Minard* was a pioneer in diagram design. He designed more than fifty graphic tables and thematic maps with statistical information. In 1861 he designed a unique *flow map* showing six different types of facts about Napoleon's disastrous Russian campaign 1812–1813. (See the book *Information Design 6–Predecessors & Pioneers*.)

Today data visualization is a modern branch of descriptive statistics. It involves the creation and study of visual representation of data. According to Friedman (2008) the main goal of data visualization is its ability to visualize data, communicate information clearly and effectively. Data visualization is closely related to information graphics, information visualization, scientific visualization, and statistical graphics. In their "periodic table of visualization methods for management" (Lengler & Eppler, 2007) data visualization includes standard quantitative formats such as area charts, pie charts, and line graphs. They are mainly used for getting an overview of data.

Educational visualization

Many kind of visualization are used in *educational visualization*. It may be topics that are difficult to see because artefacts are far too small or far too large to be studied. It may also be processes that are far too slow or far too rapid to be studied.

Iohannes Amos Comenius formulated a *general theory of education*. He was the first person to really show to a broader audience how visuals and words could interplay in an active way. In his illustrated textbook, *Orbis Sensualium Pictus* (The Visible World in Pictures) 1658, he presented information on the world and on mankind in *closely related pictures and words*. This book was widely used in both Europe and the USA for some 200 years. (See the book *Information Design 6–Predecessors & Pioneers*.)

In teaching environments visualization serve two primary functions: 1) to promote learning and understanding, and 2) to aid in analysis and problem solving (Vavra et al., 2011).

Educational visualization may probably be used in almost all established disciplines.

Geovisualization

In traditionally printed maps the graphical representations are inextricably linked to the basic geographical information. The English engineering draughtsman *Harry Beck* designed the radically simplified topological map of the Underground tube system in London (1931). The map was immediately very popular, and it has several followers in other cities. (See the book *Information Design 6–Predecessors & Pioneers*.)

Geovisualization is short for *Geographic visualization*. It allows for the creation of interactive maps with techniques and

tools used for analysis of different "layers" of the map. Geovisualization communicates geospatial data and information in ways that humans can understand and use to make decisions. It is possible to zoom in and out, and to change the visual appearance of a map, usually on a computer display.

Information visualization

Information visualization, or *visual data analysis*, usually concerns the use of computers to explore large amounts of abstract numerical and/or non-numerical data. It is a critical component in data mining, digital libraries, drug discovery, financial data analysis, manufacturing production control, market studies, social relationships, and scientific research (Bederson & Shneiderman, 2003).

Modern information visualization originated in computer graphics and in user interface design. According to (Thomas & Cook, 2005) visual representations and interaction techniques take advantage of the human eye's broad bandwidth pathway into the mind to allow users to see, explore, and understand large amounts of information at once. Information visualization focuses on the creation of approaches for conveying abstract information in intuitive ways. In their "periodic table of visualization methods for management" (Lengler & Eppler, 2007) information visualization is defined as the use of interactive visual representations of data to amplify cognition. Data is transformed into images and mapped to screen space. Users can interact with the images.

Knowledge visualization

Today *knowledge visualization* is a popular research direction. It is often defined as using visual representations to *transfer*

knowledge. According to Burkhard (2005, p. 23) "Knowledge visualization examines the use of visual representations to improve the transfer and creation of knowledge between at least two persons. Knowledge visualization thus designates all graphic means that can be used to develop or convey insights, experiences, methods, or skills." However, in my mind we can only transfer data and information between people. Then each individual has to build her or his own knowledge internally.

Product visualization

In the past technical drawings were made by hand. Now designers and engineers use advanced computer software, computer graphics, and systems for computer-aided design. They can demonstrate, document, and manipulate technical drawings and 3D models of future products. Software for product visualization often provides high levels of photorealism. Thus products can be viewed before they are manufactured.

Scientific visualization

Scientific visualization is graphical representation of data in order to be able to understand the data. Today scientific visualization is concerned with the analysis and interactive display of data. Examples are the practice of producing graphic visualizations of two- and three-dimensional phenomena in architecture, biology, chemistry, engineering, medicine, meteorology, and other sciences. The purpose is to illustrate scientific data and enable scientists to explain, illustrate, and understand their data. The emphasis is on realistic renderings of illumination sources, surfaces, and volumes. Rendering is the process of generating an image from a model, by means of advanced computer

software. Modern scientific visualization originated in computer graphics and in user interface design.

Volume visualization

Initially volume visualization was used in medical imaging. It allows viewing an object without mathematically representing the other surface. Now volume visualization is an essential technique in many sciences and are used to portray biological structures, clouds, flow of water, and molecule structures.

Image manipulation

There are pictures almost everywhere. Regardless of our wishes, we are constantly confronted with numerous visual impressions. We see pictures in public places, on TV, at the cinema, in books, newspapers and periodicals, on various types of packaging and in many other contexts as well. Never before have we had access and been exposed to–or the victims of–as many pictures as exist today. It is obvious, and perhaps a good thing, that all pictures are not salient at every separate occasion. Many actually drown in the general media noise.

Conscious and perhaps even unconscious deception, falsification and manipulation of pictures–through tampering, biased selection or improper captions–occur rather often, resulting in readers being manipulated, deluded and misled (Pettersson, 2002b). Readers are seldom or never able to judge for them what has happened before or after the moment a photograph was taken. Nor do they know what occurred in proximity to the situation in question.

Views on image manipulation

In one study (Pettersson, 2002b) subjects were asked to answer the following five questions.

1. How do you define the concept image manipulation?
2. What media do you think use image manipulation?
3. How common do you think that image manipulation is?
4. What do you think about image manipulation?
5. Can you see if an image is manipulated?

A total of 186 subjects wrote their answers on special forms. After registration of participation it was no longer possible to link any opinion to a specific person. Most subjects were between twenty and thirty years old. The 930 answers to the five questions presented more than 1,300 opinions about image manipulation. In this study it is not possible to distinguish between opinions from female and male subjects.

Definitions

The answers to the first question ("How do you define the concept image manipulation?") can be divided in categories of descriptions rather than definitions. The students have used 390 verbs or expressions in their descriptions.

Most of the descriptions (86%) explain how the "sender" somehow makes changes in the picture. Quite a few descriptions use similar expressions. In some cases synonyms are used. In the second group (14%) some answers describe "possible objectives" for the image manipulation. Thus these descriptions represent another perspective on the concept image manipulation than the first group. The five most common verbs are

change (28%), transform (15%), add (8%), delete (8%), and distort (7%).

We may note that some subjects mix up and confuse image and reality. For example four individuals have answered, "Improve reality." They probably mean, "Improve the image of reality."

Media

The answers to the second question ("What media do you think use image manipulation?") were sorted in such a way that similar answers and answers with basically the same contents are put in "media groups." This question resulted in 368 explanatory expressions for media. The most frequent answers include 1) print media (33%), 2) television (19%), and 3) "all" or "most" media with images (19%).

Occurrence

The answers to the third question ("How common do you think that image manipulation is?") were sorted in such a way that similar answers with basically the same contents are put in "types." Subjects provided 186 explanatory answers. Most students (91%) consider image manipulation to be "frequent." A small group (6%) view image manipulation to be "uncommon." A few subjects (3%) do not know that image manipulation may occur or they have no comments.

Opinions

The answers to the fourth question (What do you think about image manipulation?) may be put in five groups:

1. Image manipulation is a good thing. (6%)

2. Image manipulation is acceptable when this is clearly noted. (7%)
3. Sometimes image manipulation is acceptable. (68%)
4. Image manipulation is wrong. (14%)
5. Other views. (6%)

Thus a small portion of the subjects (14%) view that image manipulation is wrong. However, a clear majority have the view that image manipulation may be acceptable. According to many of the answers "the context, the specific situation and the objective of the sender" defines if image manipulation is acceptable or not.

The subjects also accept image manipulation in some media, such as magazines, when the topic is "fashion, advertising and propaganda." In fact several subjects expect the use of image manipulation in these media. To "improve, simplify and enhance image quality" are also quite acceptable to many of the subjects in this group.

Does it show?

The fifth question ("Can you see if an image is manipulated?") was used to clarify to what extent subjects feel that they can see if an image is manipulated or not. The answers from the 186 subjects may be put in three groups:

1. No, and denying answers. (60%)
2. Hesitating answers. (17%)
3. Yes, and affirmative answers. (23%)

Thus most of the subjects hold the opinion that they are not able to see if an image is manipulated. However, almost one

quarter of the subjects feel that they are able to see if an image is manipulated.

Validity

It may be reasonable to assume that this group of subjects have the same, or similar, opinions as other groups of subjects and as the general public regarding the definition of image manipulation. This would also be true for opinions about the occurrence of image manipulation in various media.

However, with respect to opinions about the occurrence of image manipulation this group may differ from the general public. It is reasonable to assume that information design subjects are more aware about image manipulation, and how easy it is done, than other groups of people. This would also be the case for opinions as well as if it is possible to see and detect if an image is manipulated or not.

Digital image manipulation

Digitally manipulated photographs began to appear in the daily press in the mid-1980s (Alling-Ode & Tubin, 1993; Becker, 1996; Paul, 2000). The introduction of digital pictures and electronic transmission of pictures has had a radical effect on how pictures are dealt with at various stages of production (Pettersson, 2002b) as well as on how readers perceive these pictures (Ritchin, 1990). Technical development has fundamentally changed our presumptions concerning credibility in photographs. Photos need no longer have natural ties to the film-based original (Fetveit, 1997).

Using modern computers and graphics processing programs, one can, in principle, make any conceivable change in

drawings and photographs as well as in moving pictures on film or video from the very moment the photograph is taken until it is published. For a person with the necessary skills and access to the right equipment, there are almost no limitations (Hedgecoe, 1994). Thousands of pictures of various standard backgrounds and foregrounds–depicting different types of landscapes, city environments, people, plants, animals, etc.–can be combined to form an endless number of entirely or partly new picture motifs. In this context, naturally, interesting ethical questions arise, which are neither trivial nor in any way easy to answer.

The picture to the right is digitally manipulated.

Regulations

Modern computer-based graphical systems have a lot of built-in possibilities for manipulating images. However, usually we need permission from the copyright owner, and–from an ethical point of view–also from any person in the picture. It seems that photo manipulation has become a common practice for many graphic designers working in advertising and entertainment. However, in news, information design, and instruction design,

readers and viewers expect pictures and images to represent the truth in a correct way.

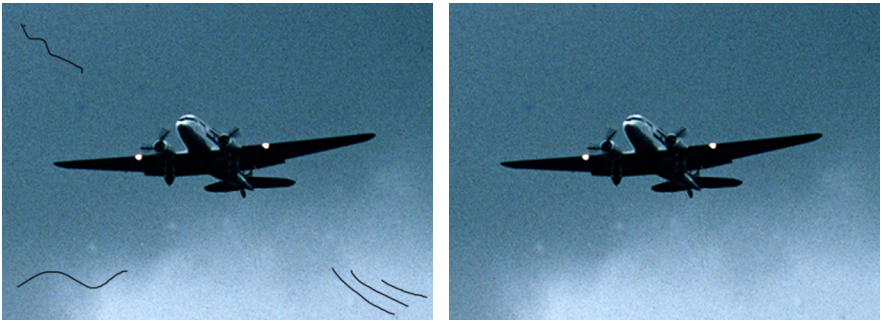
In Sweden the law relating to photography ceased to be in effect on 1 July 1994, at which point regulations concerning the right to photographs were subsumed under the copyright laws. The financial and idealistic interests of photographers, authors, draughtsmen, songwriters and other originators of creative works are protected by the copyright law relating to literary and artistic works (Copyright Act, URL, SFS 1960:729).

Since 1 January 1996, artistic works are protected for the originator's entire life plus an additional 70 years. Thus, many works are protected for more than 120-130 years. This protection is international. The economic right implies the sole right of the originator to determine duplication of the work–the making of copies and presentation of the work in public. For "picture theft" occurring intentionally or through gross negligence, the penalty is fines or imprisonment for up to two years.

Modern computer-based graphical systems have great built-in possibilities for manipulating images. However, usually we need to have permission from the copyright owner, and–from an ethical point of view–also from any person in the picture. It seems that photo manipulation has become a common practice for many graphic designers working in advertising and entertainment. However, in news, information design, and instruction design readers and viewers expect pictures and images to represent the truth in a correct way.

The ethical rules for the press, radio and TV clearly take exception to manipulation and falsification of picture content through trimming, montage or misleading captions (Bildleverantörernas Förening, 1999; Harrie, 1999; Pressens Samarbets-

nämnd, 1999). Presenting inauthentic pictures as though they were real documentary material is forbidden. The party purchasing the pictures is responsible for their proper use. Despite these rules, clear violations occur all too often, in Sweden as well as in many other countries.



Digital retouching. It is easy to change individual pixels in a picture, and thus get rid of dust and scratches. These pictures show a DC-3 flying low over Stockholm, Sweden.

Photographers and draughtsmen as well as their organisations stipulate in their terms of delivery that published pictures shall be correct. Those purchasing the right to publish the pictures may not use them in a misleading manner. Nor may they make a picture montage or retouch electronically such that the results can mislead or delude the reader or viewer. Today, one does not have the right to change the content of any picture without the express permission of the holder of the right to that picture.

According to Cifuentes, Myers and McIntosh (1998) the Associated Press has adopted photo manipulation guidelines to prevent dishonest reporting (p. 170):

1. The content of a photograph will never be changed or manipulated.
2. Only the established norms of standard photo printing methods such as burning, dodging, black-and-white toning, and cropping are acceptable.
3. Retouching is limited to removal of normal scratches and dust spots.
4. Serious consideration must always be given in correcting colour to ensure honest reproduction of the original.
5. Cases of abnormal colour or tonality will be clearly stated in the caption.
6. Colour adjustment should always be minimal.

Digital deception

However sometimes digital photo manipulation, or digital deception, may enhance a message, and sometimes it should be used for better communication. It is possible to modify an image in several different ways. We can change projection, expand, compress, reduce, delete, modify, add, supplement, move, turn, isolate, or combine various parts of an image.

Changing projection

The projection plane can be altered through image modification or shrinkage. This distorts size relationships within the picture and affects our perception of image contents. This is easy to experience when using OH-transparencies or slides without a proper set-up of projector and screen. Changing the projection plane can be used in a creative and positive way to enhance or restore the content of an image.

Expansion and compression
An image can be vertically and/or horizontally expanded or stretched. This will of course change the size relationships within the image, but may sometimes be necessary. A picture can also be compressed, i.e., squashed from the sides or from the top and bottom. Expansion and compression will always result in a more or less serious distortion of the original image. Sometimes this can create useful effects.

Changes and deletions
To focus the reader's attention on the main content in a picture, individual picture elements can be changed so as to improve contrast, acuity, sharpness, grey scale, or colour scale. Surrounding parts can be made paler, darker, or out of focus. The visual's external contour can be blurred and unclear so the picture fades in/out of the background. Good photographers select focusing and depth of field to achieve the same goal–better clarity and better communication. The grey scale can sometimes be transformed into optional colours.

Individual picture elements, as well as groups of picture elements, can be moved or turned around within an image for the sake of better balance and harmony. Groups of picture elements can also be copied from one place in an image and moved to one or more other positions within the image. It is also possible to move parts of an image to other pictures.

A picture can be tilted on the page at will. Tilting of a picture may draw special attention to it. Distracting or undesirable details in a picture can be removed by painting with an appropriate retouching colour or shade. This is also a way to isolate parts of a picture by, say, peeling and cropping. The detail can

then be used independently or as a part of other pictures. Deletion can be used for partial silhouetting of a picture so that an important part of the picture pokes beyond the frame. Deletion can also be used for full silhouetting to get rid of all background disturbances. The outline of an image can be softened.

Additions

The relation between width and height of the image can be changed by the addition of space. To achieve emphasis it is common to add information such as shadows, contrasts, colours, signs, and symbols. Letters of the alphabet, numerals, lines, arrows, circles, and other symbols or markings can be added to a picture for the purpose of enhancing image content and focusing attention to specific parts of the image and links to the caption. The super-imposition of text onto a picture image usually impairs our ability to absorb the contents of both text and picture.

Groups of picture elements can be copied from one place in an image and moved to one or more other positions within the image. It is also possible to move parts of an image to other pictures. Parts in a picture can be added by painting with an appropriate retouching colour or shade.

Image framing makes a clear distinction between image and background. An image may be framed in a frame appropriate to the subject. The frame may be a window, a keyhole, or the like.

Converting photos

McDougall and Hampton (1990, p. 32) noted that converting photos to art is a type of photo theft that picture editors should

crack down on. It is far to common that artists transform photographs to artwork for use as illustrations in newspapers and books. To transform a photo into a drawing is not only unethical, it is also often an infringement of copyright. McDougall and Hampton writes: “The courts have held that a work of art which has been copied from another work which is copyrighted, regardless of alterations, is primafacie evidence of copyright infringement. The courts have also held that copying a work of art in a different medium such as changing a photo into a drawing is still a violation.” There are, however, also examples of the opposite.

A definition of image manipulation

People used to make retouch on photographs using a brush and Indian ink. Today such operations can easily be performed in the computer. However, in my view it is not enough to consider these kind surgical changes in pictures as image manipulation. In my view we need to consider two different types of image manipulation.

1. No change of any picture elements. People's perception of reality can be influenced and steered in a desired direction through well-considered selection of pictures, careful trimming as well as leading captions.
2. Change of certain picture elements in order to influence people's perception of the reality the picture appears to depict.

Based on these distinctions I have proposed the following definition of image manipulation (Pettersson, 2002b): “Image manipulation implies the improper control of people's perception

of a given reality through the use of pictures." Thus effective use of computers and digital technology for editing and production of good quality pictures does not have to mean image manipulation.

It is obvious that technical development has fundamentally changed conditions for our ability to use pictures in different contexts as well as for the credibility of all pictures. In practice, individual newspaper readers and TV viewers no longer have any real opportunity to discover whether a published picture has been manipulated or not. We can hardly assume that this situation will improve in the future since computer technology is developing rapidly. With each passing year, it becomes easier for anyone to create and revise pictures, and make them accessible to others on the Internet.

Difficulties, as well as mistakes and deception, exist within news reporting. So far we don't know how to answer the questions: "How can we best 'protect' ourselves from being manipulated by, for example, news reporting? Can we trust the pictures we see? How can we expose deception?" We can, of course, hope that the established media actually assume their responsibility and live up to their own rules. Rules and ethical norms are already in place, but it is evident that all people working in media are not aware of the great responsibility they bear. In the long run this lack of responsibility could lead to a credibility crisis for the news media. If we become accustomed to deception, our trust in the media will diminish.

Good rules and norms, however, are not enough. What is also needed is that people working in media learn them, and that readers and viewers adopt a critical approach to media. To achieve this, pictorial communication, critical analysis and

source criticism must become a real and natural feature of teaching in school.

It is conceivable that future generations–growing up with increasingly advanced computers and learning to use them early in life–will develop a freer and more independent approach to pictures and pictorial communication than the one characterising adults of today. Children who learn to work with pictures on computers should find it easier to understand what can be done. When these children are grown, pictures will no longer have any "natural credibility" for them (Pettersson, 2001b). They will not expect, for example, that advertisement pictures even attempt to reflect any form of objective reality. At this point, we know little about how pictures function as communicative expressions. There is a great need for research, development work and education regarding the role of pictures.

Image formats

Our perception of a picture is affected by its medium. Our perception changes when we view the image as a photographic copy, as a printed picture in a book, as an image projected on a white screen with a projector, an image in a viewfinder, an image on a computer-screen, or an image on a television screen, etcetera. A movie evokes completely different perceptions when a viewer watches it alone on television or in a crowded movie theatre with a wide-screen and high-quality sound and images. An image is a multidimensional representation of an inner or external reality, depicting the physical structure of the objects or events it represents.

An image can also be described as a more or less complicated sense of vision, i.e., awareness of the stimulation of the eye's vision perception cells, with a specific message or content. An inner image, a visual experience, can originate in thoughts and in dreams. It may be caused by words, e.g., a picture description, without any help of pictures. Every possible visual, every format has different possibilities of supplying specific message or content. This depends on the choice of material and type of production.

Image morphology

Mirror images and other virtual images, created by mirrors, lenses, and other optical systems, can be seen but not "captured" and shown on a screen of any sort. A *virtual image* is located in a point from which divergent light beams seem to start before they have passed the optical system. Like our inner

images, e.g., memories, virtual images lack an obvious physical format. All other kinds of images have a physical format.

Combinations of small elements

An artist or a painter producing a picture may use lead, crayons, India ink, various kinds of paint, paper, canvas, and several other kinds of material in a variety of different combinations. Combinations of dots, lines, and areas gradually produce the image. The actual picture is built up from materials and pigments that, according to intentions, can be completely separated or gradually mixed. In technical systems the whole motif may be captured at once with a traditional camera, or it may be scanned line by line with a TV-camera. Except for the printing of line drawings, all other pictures have to be divided into small elements, picture elements, or pixels, in the technical process of duplication, e.g., in the printing of books or in the broadcasting of television. The image has vertical (y) and horizontal (x) resolution and it has also "depth resolution" (z). An individual pixel may vary with respect to shape, size, position, value, grain, colour, and grey scale.

Normally these pixels are very small. At normal reading distance they can hardly be seen. In fact an image with "good quality" must have a resolution that is better than that of our own vision. In real life, nature and all kinds of objects have got an infinite number of colour nuances and shades of gray. Our perception system can handle enormous quantities of information under very different conditions. At any given moment, the eye may contain 2,500,000 bits of information. We can see one detail that is a 1,000 times brighter or darker than another detail. For 35-movie film this range of contrast is 100 and for tele-

vision it is only 10-20. Yet our eyes are by no means “perfect” optical systems. The eye has inertia. It takes time to read an image. This inertia enables us to see the motion in the stills that comprise movie film and television. Movie film usually uses 24 pictures and PAL-television 25 images per second. This is just below the so called “flicker threshold” which lies at about 27-28 images per second. At higher picture frequency the eye can no longer keep up. NTSC-television uses 30 images per second and thus gives a more stable television-image than PAL-television.

It is possible for us to see the difference between several millions of colour stimuli at simultaneous viewing. However, if not being seen simultaneously the number we can identify is much smaller, maybe 10,000 to 20,000. It is often claimed that we can only identify 64 shades in a gray-scale. There is also a limit to acuity. Acuity is best in the fovea, and considerably worse outside it. Take a close look at a colour-television-image (about an arm's length distance). In the very centre of the gaze you are able clearly to see the small red, green and blue dots or bars (depending on the model) making up the television-image. This clear oval or circular area, between a dime and a quarter in size, is falling on the foveae in your eyes. It will jump around as you move your eyes over the image and make four to six eye fixations per second. At normal television-viewing distance all the small dots blend together and we may perceive the image as “rather good” or “good.” More pixels are needed to make a really good television-image (more below). The maximum resolution is the same as the distance between two cones in the retina with one non-activated cone in-between. This corresponds to some 200 pixels per millimetre (5,000 pixels per inch) at normal reading distance. The necessary number and size of

individual pixels will be defined by: 1) The size of the object depicted. 2) The size of the image. 3) The viewing distance. 4) The image content. 5) The actual material carrying the image (paper, film, glass, etc.).

Close viewing distances require the images to be divided into many small pixels. For long viewing distances it is enough with fewer and larger pixels. And pixels really vary in size, and they also represent very different parts of reality. Some examples will be given here to illustrate this.

The first American Land sat-satellite was sent up in 1972. Landsat-1 registered green, red and two bands near infrared. Pictures cover 185x185 kilometres on earth. Each pixel represents 80x80 metres that are 6,400 square metres. Landsat-1 was a great success and was followed by Landsat-2 in January 1975 and by Landsat-3 in March 1978. Since 1982, the Land sat-satellites produce images with a resolution of 30 metres. Each pixel has been reduced to 900 square metres. In February 1986, the European SPOT-satellite was launched into orbit. The SPOT-satellite delivers images with 20 metres resolution in colour and 10 metres resolution in black and white. Now the pixels were reduced to 400 and 100 square metres respectively. Usually SPOT-pictures depict 60x60 kilometres of the surface of the ground. Such a black and white "scene" has got 6,000 lines with 6,000 pixels each that is a total of 36 million pixels. At Esrange, the premises of the Swedish Space Corporation in Kiruna, in northern Sweden, a quarter of a million SPOT-pictures are received every year. With pictures like this it is possible to produce several kinds of maps for use e.g. in agriculture and forestry. Certain military satellites, "spy-satellites," are suggested to produce pictures with a resolution of only a few deci-

metres. Then it is possible to distinguish individual people for example on board a ship. When a SPOT-scene and a photographic portrait of a person are printed with the same resolution as full pages in the same book, a pixel in the first image represents a portion of reality that is one million times larger than the area represented by a pixel in the second image. At the 1980 Olympic summer games in Moscow some 3,000 Russian soldiers holding square textile fabrics in different colours produced several different images. The image of Mischa, the Russian bear, became a symbol of the games. When we see the tracks and trails left by animals in snow or in soft mud these "visuals" may tell you a lot about the animals and their activities. Skilled hunters will "reed" these visuals as we read pictures in a book. Such a visual may consist of just a few pixels. A single footprint from the hoof of a horse is in fact a one-pixel-picture. Take a shower, a bath or a footbath, and then walk across the floor. Your footprints will be pictures consisting of just a few pixels.

The Jumbotron, the largest video-screen in the world was 25x40 metres, equivalent to a ten-storey building when it was presented in Japan in 1985. The Jumbotron-image, which could be seen by more than 50,000 people at the same time, consisted of 150,000 picture elements. Each picture element was an 8x4.5 centimetre TRINI-LITE cell with a blue, a green and a red section. A computer system was used to control all the different pixels individually.

For a few thousand years artists have produced mosaics as decorations on floors, walls and roofs. Mosaics consist of thousands of small pieces, usually of glass or marble in different colours. Each piece is carefully put into a soft foundation that

then hardens. The large mosaics in the cathedral of St. Peter in Rome and in many other churches are seen as actual paintings. One has to get really close to the images to see the individual pieces of glass-pixels. For thousands of years man have produced images on various textiles such as pieces of embroideries, pieces of knitting, pieces of crochet works, pieces of needlework, woven fabric tissues and tapestry. Different kinds of yarns and threads have been used to make stitches, seams and knots. In a textile picture these stitches, seams and knots are the pixels.

In the production of enamel signs, which were quite usual at the last turn of the century, it was necessary to use very stylized images. To be able to produce templates that would last when excess paint was brushed off fine details could not be used. The result was a unique and distinct sharpness that we still can admire. Another example of picture elements is intarsia, decorative wood works. Each wooden piece is a pixel. All are different with respect to shape, size, colour and placement.

Perception of pixels

Pixels are always small in relation to the screen on which they are displayed. The greater the number of pixels used by a system for image formation in a given area, the greater the system's sharpness and resolution. When resolution is good, a black or white pixel cannot be distinguished from other adjacent black or white pixels. This applies both to monitor screens and copies on paper, plastic, or film. However, an individual white (or black) pixel is highly visible when surrounded by black (or white) pixels.

When black and white pixels are evenly distributed in an image, individual pixels become indistinguishable. The image

then assumes a grey appearance. Thus, our perception of an individual pixel is always heavily influenced by the context in which the pixel appears. The relative distribution of black and white pixels, or the "sum" of each pixel's context, is decisive to our perception of image content. Purely random distribution of pixels produces a grey, uninteresting pattern. A controlled, intentional distribution of pixels can result in different patterns or depictions. Moving or changing the pixels in a picture enables us to create thousands of new images. Computers process each variation as a different picture. But a human viewer may regard these images as functionally identical and equivalent. Analogously, a text can be presented in many different ways, with different typefaces and pitches, etc., with no major effect on perception of the text's content.

Normally speaking, an individual pixel is insignificant from a visual language point of view. A surprisingly large number of pixels can be deleted from an image. When performing image analysis, a computer is usually incapable of deciding whether or not an individual pixel is significant to the image. A pixel may be an important feature of a basic graphic image element (a dot, a line, or an area) or of a simple shape, thereby contributing to a visual sub-meaning or syntagm. So we can delete, add, or shift information in an image without drastically affecting perception of image contents. The pixels that form borders or edges between different shapes are more important to picture perception than other pixels. Since the brain fills in missing information and always strives to make the best possible interpretation of a given stimulus, the deletion of even some meaningful parts of a picture is also possible.

In cartoons, absent lines can be as important as the lines actually present. The ability to utilize the “right” amount of graphic image elements and to find the “right” balance in a picture is characteristics of experienced and skilled artists, photographers, and graphic designers. Too little information results in an inadequate picture. Too much information results in a picture that is hard to decipher and comprehend. There is an ideal trade-off for every type of picture content and for every application.

Analogue and digital coding

Whether data is stored with analogue codes (as continuous signals) or with digital codes (as sequences of discrete values, written with binary ones and/or zeros) are of major importance. Analogue coding takes up much less space than digital coding. Video data stored in analogue form is suitable, for example, for entertainment when sequential viewing of a program from beginning to end is desired.

The following example illustrates the difference between analogue and digital storage of data. A single page of a book can hold about 2,500 characters (i.e., 50 lines containing 50 characters, including spaces between words). Storing the same book page in digital form would require 20,000 bits of information. This may seem like a great deal but it is still almost negligible compared to the storage and transmission of data in other media.

Here are some equivalents: a line drawing is equivalent to five pages text, one second of FM radio to ten pages of text, one second of digital sound on a compact disc to 35 pages text, one second of television to 250 pages text, one second of HDTV to

1,500 pages text, and one frame (a scene) from the SPOT-satellite is equivalent to no less than 50,000 pages with text. Thus, digitally stored data always takes up much more space than data stored in analogue form. Provided that the number of pixels is large enough, digitally stored data offers numerous opportunities for easy and convenient "manipulation" and editing of text, sound, or image in different ways. This may be highly important in different kinds of interactive applications, such as multimedia systems for education and training.

The editing of a written text can result in the production of a message with fewer words. In speech synthesis, i.e., computer-generated speech, the amount of transmitted data can sometimes be reduced by 99% with no loss of message comprehension, even if the aesthetic quality of speech may decline considerably. In a similar manner, the number of pixels in an image can be reduced without any major impact on the image's message. Thus, it is possible to more effectively make use of computer memory capacity. A bit-mapped image, created and stored in a computer may be scaled. However, no new information is added when the image is enlarged and important information is lost when the image is reduced. Thus it is normally best to create an image in the correct size.

Computer images

Computer images are digital. In some image systems the square or rectangular pixel is either white (light) or black (dark). In other systems the pixels can be varied in a grey-scale and/or in a colour range. The number of colours that can be reproduced depends on which computer, which operating system, which program, and which computer screen is used. Quite often eight

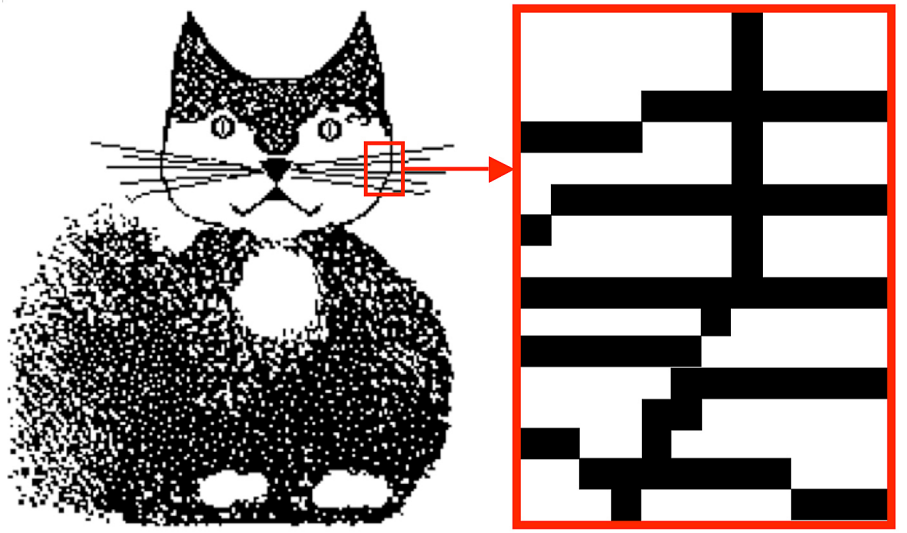
bits of information is used for red, green, and blue colours, respectively, and eight bits for text and graphical effects. Each colour can be stored in 256 levels. In total it is possible to create 16 millions of nuances in the image. Pixels are always small compared to the screen. More pixels within a given area provide better sharpness and more details in the system. Pixels in large systems can actually be much larger than whole screens in smaller systems.

Creation of computer images

Computers are capable of displaying many kinds of pictures on their monitors. Rapid technological innovations constantly increase the range of images displayable by computer. Computer-displayable pictures are always converted to digital form at some stage, i.e., a series of zeros and ones. Several very easy-to-use drawing programs, charting programs, and even digital clip-art files make it possible for anyone to create simple but good-looking graphics and other line drawings.

Pixel images

A *pixel image* or a *bit-mapped image* consists of a large number of small pixels or picture elements, e.g., small squares. These pixels have either a colour (usually black, but they may also be e.g. green or blue, depending on the design of the screen) or no colour at all. All pixels have the same size. In “paint-programs” you have a lot of different painting tools. You can draw all kinds of figures in free hand and you can easily change any individual pixel. Bit-mapped graphics can be modified, stretched, condensed, inverted, rotated, and outlined. Paint-programs are effective multi-purpose drawing tools.



In an image created in the computer with a low resolution (72 dots per inch) it is easy to see the individual pixels. In the enlargement it is easy to see that each square pixel is either black or white.

A number of "clip art" packages containing ready-to-use drawings of people, buildings, cars, boats, tools, animals, plants, etc., are available. Clip art programs are usually created in bit-map technique. The drawings may easily be changed and modified to fit a special style. Like all other computer pictures they can be integrated with text.

When a bit-mapped image is printed the black pixels get the colour of the print medium (usually black), and the white pixels get the colour of the paper (usually white). The quality is defined by the quality of the printer. The better the printer, the better the technical quality of the picture. The relative distribu-

tion of printed and non-printed pixels builds the image. The more pixels, the better the resolution. Normally the resolution is not at all "good enough" to create a suitable picture. This is especially true if we need to change the scale of a picture. Apart from lines in vertical and horizontal positions, all other lines get a rugged appearance. The image quality is the same when printed with a laser printer or with an advanced phototypesetter.

Vector images

A *vector image* or an *object-oriented image* is based on mathematical functions and is composed of lines and closed polygons. A coordinate system holds all the information on where lines, circles, squares, rectangles, and other shapes start and stop. Shapes can be filled with various patterns and delineated with different lines. This means that an image can be scaled up and scaled down without loss of quality. The image is re-drawn according to the specifications set by the new size.

Computer systems are being used to an increasing degree for editing, correcting, processing, retouching, and supplementing the contents of pictures for books, magazines, or other printed matter, and for slides and overhead transparencies. The basic picture, such as a drawing or photograph, must be digitized with the aid of a scanner or special video camera. The computer can then feed the digitized images to some peripheral such as a laser printer, dot matrix printer, plotter, film, or a printing plate.

Hybrid pictures

The production of charts and graphs may be very time-consuming. Several computer programs can convert traditional

tabular data to various kinds of graphics. These programs allow you to enter all the values needed, into a spreadsheet-style grid. They take the information, do all the calculations and present the results as line charts, bar charts, pie charts, scatter charts, and combinations of those styles. Once data is entered you can usually choose from several different presentations. Using programs combining the bit-map creates a hybrid picture and the object oriented programs.

Computer-generated pictures

The concept of computer-generated pictures, i.e., computer graphics, is employed in many different ways. However, image generation by computer is the common denominator.

Computer art

Computer art is a young art form comprising visual presentations whose aesthetic aspect predominates. Computer art consists of images created on an interactive basis and of images and patterns generated at random. Computer art often contains animated sequences and is displayed at, e.g., exhibitions, art galleries, etc. Computer art can also be displayed on paper. Image information is often stored pixel-by-pixel, and not as mathematical functions.

Information graphics

Information graphics may be divided into several subgroups. Computer often generates business and news graphics. Sales, stock, or production statistics are often illustrated with graphics. If the values of individual variables are stored separately, the user is often able to illustrate the information in different ways. Histograms, bar charts, pie charts, or curves are examples

of available options. The graphics are often reproduced on film (as a slide or overhead transparency) or on paper. Graphics are being used to an increasing degree for presenting information in research and development.

Design pictures

Design pictures comprise the subgroups of drawings, maps, and patterns. Drawings, two-dimensional representations of mathematical descriptions of objects, can be generated by various CAD (computer-aided design) systems. The systems are often able to "twist and turn" a depicted object to show it from different angles before the object ever leaves the drawing board stage. Car parts, ships, aircraft, machinery, buildings, etc., are examples of objects being designed with the aid of CAD. CAD systems are often used in conjunction with CAM (computer-aided manufacturing) systems. Maps are successfully produced in CAD systems, combined with vector systems. The systems make it easy to change both the scales and contents of maps. Patterns, e.g., for textiles are also produced in CAD systems. But these CAD systems can also be used for producing patterns for, e.g., wallpaper, wrapping paper, and book covers.

Entertainment graphics

Entertainment graphics such as electronic games and animations are also produced in computer systems. Many kinds of interactive electronic games are on the market. Players manipulate space ships, robots, heroes, and bandits in fantasy worlds. The electronic games often feature dramatic colours, symbols, changes in perspective, and sound effects. Developments move at a furious pace. Only a few years ago, graphics were very

primitive, but their sophistication and resolution have been vastly improved. Animation is becoming increasingly commonplace. Computers are being used to create advanced animation effects in movies, TV, and video.

Measurement pictures

Measurement pictures are representations of various measurements in, e.g., medicine. Ultra sonograms and CAT scans are examples of pictures employed for identifying differences in the density of body tissues. The brain's activity can be visualized and measured with a positron camera. Measurement of thermal radiation is another example.

Satellites with multispectral scanners continuously record and transmit digital TV images of the Earth. These images are analyzed and used for many different purposes in meteorology, geology, agriculture, and forestry. The interpretation of satellite pictures is a widespread activity. Photographic pictures are also used for a wide range of military applications.

Computer screens

Computer screens can be constructed and manufactured in many different ways and have very different characteristics. Examples are fog screens, head up displays, light emitting diodes, liquid crystals, magnetic field boards, picture tubes, and plasma screens. Computers may also be connected to different kinds of projection systems.

Fog screens

A fog screen is a technology that allows projection of images on a screen in the air. This projection technology creates an illusion that images are floating in midair.

A suspended device produces a thin wall of mist, a "dry" fog, which is blown down between two curtains, or layers, of air streams. The fog is produced from ordinary water and consists of tiny water particles, a few microns in diameter.

Two video projectors can be used to project different images on both sides of the screen. People can walk through the screen with the images. Fog screen technology can be used for a large number of applications.

Head up displays

A Head Up Display, HUD, is a special type of helmet used in advanced flight simulators and in Virtual Reality systems. Computer generated images are projected by fibre optics onto the curved visor in front of the pilot's face. In the simulator the pilot gets a flying experience that is suggested to be true to life. In simpler simulator systems computer-graphics are projected onto several screens, replacing the windows, or located just outside the cockpit of the boat, car, or aircraft.

Light-emitting diodes

The picture area in LED-displays may be very large. The resolution is 6,400 pixels per m^2. The pixels consist of red and green light-emitting diodes with high efficiency, i.e., low power consumption and long life. So far no blue diodes have been developed. Screens with light-emitting diodes are used for advertising. By turning the diodes on and off it are possible to create

simple animations, for example, text and simple graphics moving across the screen.

Liquid crystals

Liquid crystals can be used for instrument displays or screens. An LCD, Liquid Crystal Display, contains a liquid whose molecules lie parallel when an electronic current passes. Between polarizing filters the crystals then look dark. The technique is common in, for example, wrist watches. Here every element in the digits is connected so that it can be turned on and off. In larger screens there is a net of crossing semi-conductors behind the crystal layer. A dark dot appears in every crossing when the current is turned on. A picture is built up quite slowly. A FLCD, Ferro-electric Liquid Crystal Display, is a flat screen with liquid crystals. The ferro-electric crystals work tens of thousands times faster than the normal LCD. They give better contrast and use less energy.

Magnetic field boards

An electronic magnetic field board consists of small hexagons containing a black magnetic material, like iron filings. Close-up the board looks like a honeycomb. By using a magnetic head, a "page" with text or images can be built up. The board is "erased" by changing the magnetic field. It is also possible to write directly on the board with either a magnetic pen or with markers of different colours.

Picture tubes

A picture tube or a cathode ray tube is the unit that produces and shows the picture on a television-receiver, computer, or terminal screen. The picture tube consists of an airless glass-

tube. Its rear end contains a device that emits electronic rays, while the front part forms the screen. The back of the screen is illuminated when hit by the electrons. A picture is built up by steering the ray over the screen. The additive combinations of a limited amount of radiation can produce range of colours. The additive colour combination starts in dark adding light to produce colour. The size of the screen is measured diagonally in inches. A colour television screen has a shadow mask with many apertures in it. A computer screen has instead vertical slits that give better resolution and a more stable picture.

Plasma screens

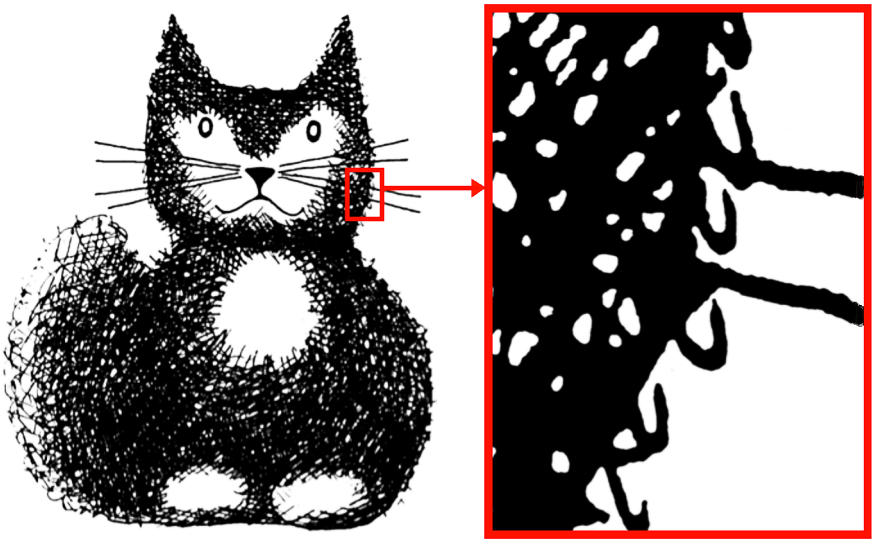
Plasma screens are flat screens with a network of anodes and cathodes. When the points are made live, a neon-like gas starts glowing. Plasma screens are sharper but require more energy than LCD-screens.

Graphical pictures

Single copies of graphical visuals can be hand-crafted using different techniques like drawing with a pencil, charcoal, crayons, and pens; painting in water colours, acrylics, oils, etc. Multiple copies of graphical visuals can be produced using technical equipments for printing, print out, or copying. There are many kinds of visuals and we can use several different criteria for classification. As far as production technology is concerned it is practical to distinguish between line-art or “full-tone pictures” and “half-tone pictures” like photographs.

Full-tone pictures

Dots, lines, and areas of solid paint build up all line-art, or "full-tone pictures." Line drawings, schematic illustrations, maps, and business graphics all belong to this category. Full-tone pictures can be in black-and-white as well as in colour. When colour pictures are printed we need one printing plate for each colour. To be able to achieve this we have to produce one original for each colour. Thus, the picture is "manually" divided into its various colour components.

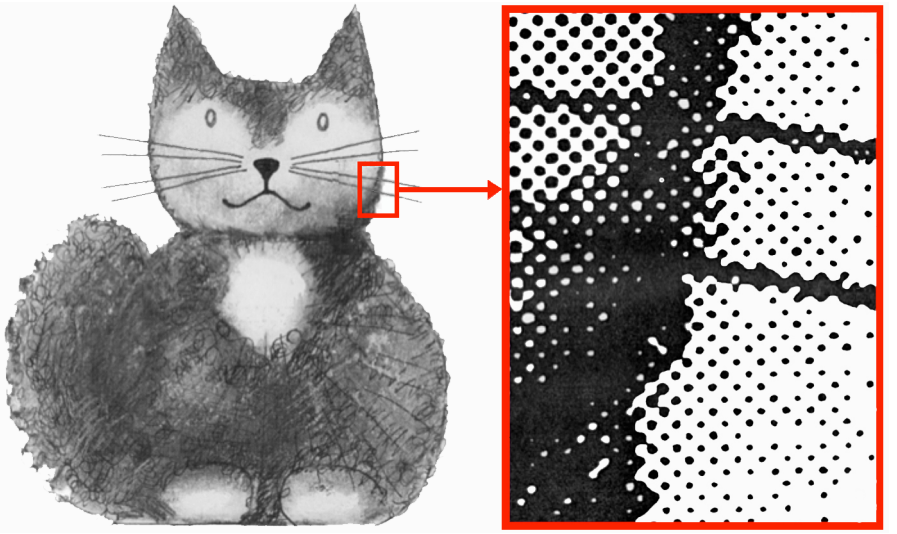


This is a line drawing, with an enlargement to the right.

Half-tone pictures

To be able to reproduce the fine nuances of a photograph or fine art the original must be divided into small picture elements. A reproduction camera is used for photographical separation

(analogue technology). Here raster-screens are used to transfer the original image into a raster-image. It is also possible to use a scanner (digital technology) to create the raster-image. In the scanner a light beam scans the complete picture area. The beam "reads" all the nuances in small parts of the picture. This information is converted to the raster-dots that are employed in the printing of the picture. In both cases the number of raster-dots will define the quality of the final printed image.

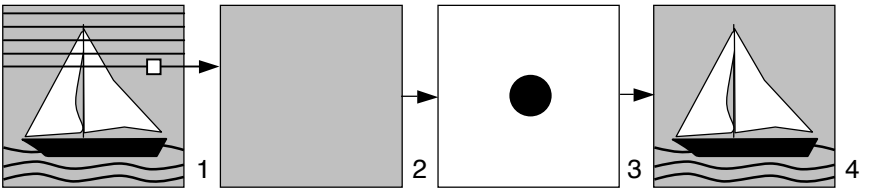


The raster pattern is easy to see in the enlargement.

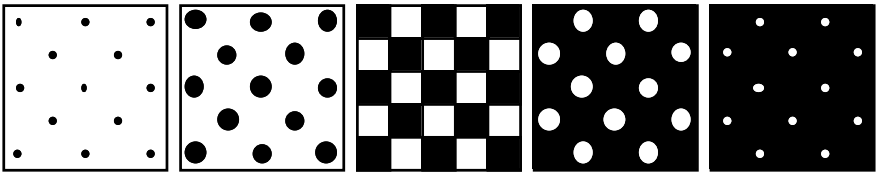
Black and white pictures

The photos we see in books and newspapers are really collections of small dots. These printed dots vary in size within the fixed "pixel-area" from nothing or a very small dot to gradually increasing dot-sizes, until the dot covers the complete "pixel-area." Smaller dots give the impression of light grey areas in the

image, and larger dots give the impression of darker tones. Thus, it is possible to reproduce photos, drawings, and other originals with (perceived) scales of grey. (Note that half-tone raster patterns will only simulate grey. This is possible due to the imperfection of our vision. The only way to really achieve a grey hue is to print the image with grey printing ink.)



A photograph 1) is read in a scanner e.g., with 100 lines per inch. Then each registered "pixel-area" 2) gets a mean value between 0 and 100% of, e.g., black. In the phototypesetter this "grey level" is transformed to a raster-dot within the pixel-area (3). The raster-dots can be created with a resolution of, e.g., 1,200 lines per inch. In the printed picture 4) the individual printed dots may be seen with the aid of a magnifying glass.



Examples of five "raster patterns" with increasing size of the individual raster dots (from less than 10% to more than 90% of black.)

In newspaper production, raster screens with a density of 50 to 65 lines per inch may be used in the pre-press process. For book production, raster screens with a density of 100 to 133 lines, or more, per inch may be used. Higher-quality printing allows half-tone raster screens of up to 300 lines per inch, resulting in images with dots so small that you can hardly see them at all. The films that are used to make printing plates may be produced using photo-typesetting machines, working with resolutions of 600 lines per inch for the newspaper plates and 1,200 lines per inch for the book plates. An image, say a two by two inch portrait, may be printed with 10,000 dots in a newspaper and 40,000 dots in a book. A large outdoor placard printed with low resolution may be at least one thousand times larger than the same advertisement printed with high resolution in a magazine. Both images may have an equal number of pixels.

Colour pictures

Images in colour have to be separated using different colour filters. This can be done photographically with a reproduction camera (analogue technology) or electronically with a scanner (digital technology). Images in colour are separated into four different half-tone films: blue, yellow, red, and black. A printing plate is generated from each film. The picture is then printed in each colour, resulting in a “four-colour-process” visual.

Looking at a picture printed in colour we experience a subtractive colour combination. The inks, dyes, and pigments function like filters for the white light. The light is absorbed in different ways. When printing on white paper, yellow and red ink produce orange. Blue and yellow create green. Red and blue give purple. Yellow, red, and blue will become black. However,

since black ink is used for printing of the text, it is also used for the printing of pictures. The black ink gives the picture a distinct sharpness and more solid dark parts. To achieve the best possible print quality the red colour that is used (magenta) is somewhat violet, and the blue colour used (cyan) is somewhat light. For the printing of black and white pictures, only one film and one plate are needed.

The easiest way to understand printed dots is to examine a printed picture. In a newspaper, the printed dots can be seen with the aid of a magnifying glass. On outdoor advertisements, and posters we can often see the individual printed dots even without a magnifying glass if we look at it from a normal reading distance.

Scanners

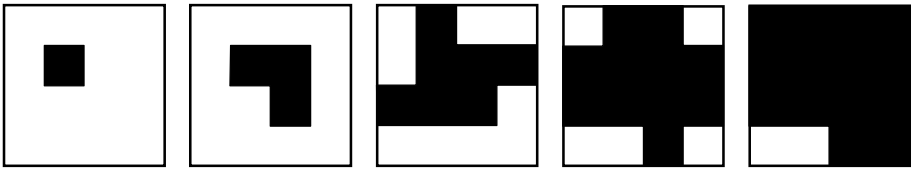
There are several types of scanners, from equipment designed for amateurs to equipment for professional use. Desktop digitizers and drum scanners will be mentioned here.

Desktop digitizers

Since photography includes a full spectrum of greys it is not possible for a computer, working in a bit-mapped mode, to represent the shades of grey. It can only show black and white. There are different kinds of digitizers. A scanner allows the user to digitize all kinds of illustrations on a paper. Desktop scanners work with CCD-technology (Charge Coupled Device). A CCD-cell consists of a number of light sensitive crystals that can transform light into digital codes. Most desktop scanners work with 300 or 400 dots per inch. The scanner can digitize an image either as a full-tone picture or as a half-tone picture. In

full-tone pictures each pixel is black or white. However, desktop systems are more or less only at a halfway point in the reproduction of photographs and fine arts. The low resolution of computer screens, scanners, and laser printers, and the vast amount of storage that it takes to store a high-resolution image electronically make digitized images possible only as low-quality simulations of photographs.

A laser printer with a resolution of 300 dots per inch uses different half-tone matrixes. A four by four pixel matrix gives a print resolution of 75 dots per inch. Each matrix contains 16 pixels. Thus there are 16 (or actually 17) different grades of tone on each "print dot." When the number of tones increases the resolution decreases. To get a satisfactory result at least 50–60 grades of tone are needed.



Here are examples of five print dots in a 4 x 4 matrix (1/16, 3/16, 7/16, 11/16 and 14/16).

The digitizing of half-tone pictures requires a lot of computer memory. Each pixel is stored in a number of bits, representing the gray scale. Four bits per pixel give 256 grades. In colour separations eight bits are needed for red, green and blue, e.g. 24 bits per pixel. And a picture needs several thousands of pixels. In fact when the resolution is only 100 lines per inch one A4-page consists of more than 5.8 million pixels. A black and

white halftone will need 35 million bits for 64 grades of gray. Only professional printers can produce really good halftones.

It is possible to adapt the resolution to available printers, for example to laser printers with 300 or 400 dots per inch, as well as to photo type-setters with better print quality. The scanning speed depends on the resolution and varies between 8 seconds for 100 dots per inch and 62 seconds for 800 pixels per inch. A hand-held scanner is moved slowly over an image on paper at an even pace. The hand-scanner reads a ten centimetre wide strip at a time. The resolution is usually 400 dots per inch and 16 gray levels. A graphic input tablet allows you to digitize an image by tracing the lines on a drawing with a hand held device like a mouse.

Professional scanners

Flatbed scanners or laser scanners are large scanners, with high resolution, working with colour or black-and-white. Large systems for integrated image and text processing often contain a *drum-scanner*. The original, a slide, or a print is fixed on a rotating drum. A laser beam reads the picture with a resolution of up to 300 lines per inch creating up to 75 dots per inch for yellow, cyan, magenta, and black, respectively. The digital image information can then be processed in different ways. It is possible to change the scale, crop the picture, and manipulate the contents. It is, for example, possible to move picture elements, make copies, put in text or symbols, etc.

Printers

Several types of printers can print digital computer pictures. Several types of printers can print digital computer pictures.

Colour bubble-jet printers, dot matrix printers ink-jet printers, laser printers, phototypesetters, plotters, telefax, telephoto, and thermal printers will be mentioned here.

Colour Bubble-Jet Printers

In this printer each of four high-density bubble-jet print heads has 128 vertically arranged nozzles. With this printer digitally stored images can be printed in full colour with a vertical and horizontal resolution of 400 dots per inch. The maximum image width is 472 mm. Plain paper, in 50 metre rolls, is used. It is possible to use four out of seven colours (black, red, green, blue, yellow, magenta, and cyan). In this system all ink dots have the same size. However, the number of dots within an area can be altered. Many dots create dark tones and few dots create light tones. Each nozzle has a heater. When the heater operates the heat produces small bubbles. Ink evaporates abruptly and the bubbles inflate. After cooling, each bubble contracts. The ink splashes out of the nozzle and the bubbles disappear. A colour bubble-jet printer can be used e.g. as a terminal for computer graphics, or for simulations of colour plate making in the printing industry. The print speed is 2,000 dots per second per nozzle. This means that 1,024,000 colour bubbles can be produced every second. A colour picture in A2 format is printed in 8 minutes.

Dot matrix printers

A dot matrix printer is an impact printer. It produces dot matrix characters by pressing thin needle points, “needles” arranged in a matrix pattern, 5 x 7, 7 x 7, or 7 x 9, to a carbon paper or a ribbon lying close to a paper. The needles form different characters, letters, digits, or parts of a picture. Dot matrix printers

work with a resolution of 50-100 dots per inch. This is the same resolution as that of many computer screens but considerably inferior to the printout quality of laser printers.

Ink-jet printers

An ink-jet printer is an impact printer where the characters are formed by an ink jet on normal office paper. The ink-jet printer does not work with raster-dots but varies the number of ink drops within a given area. Few drops give light colours. Many drops give darker colours. The system is thus creating the same kind of effect as the systems working with halftone pictures. Many ink-jet printers work with pictures printed out with a resolution of 200-250 dots per inch.

Laser printers

A laser printer is an electrostatic device in which a laser beam is scanned across the surface of an electrically charged selenium coated drum. This is done with a rotating polygonal mirror. The charge of the drum surface is modulated according to the dot matrix character patterns. A whole page with text and images is built up by a page description language (for example, PostScript) and then transferred to a paper as in a conventional Xerographic printer. Laser printers often have had a resolution of 300 or 400 dots per inch. For these printers it is hard to reproduce more than a few grey levels. When printing many grey levels the dots get far too large and the resolution too poor as they are built up by available "dots." However 1,200 dots per inch horizontally and 600 dots per inch vertically are enough for good reproduction of half-tone pictures. Most laser printers have one toner that mainly consists of black coal powder. There

are also toners in blue, brown, green, yellow, magenta, cyan, and red.

Phototypesetters

A phototypesetter usually works with high quality such as 1,250–2,600 dots per inch. This is good enough to create very small and close raster dots and to reproduce a great number of grey levels. Printouts are made on photographic materials, paper, or film, which are then used to produce printing plates. In order to get really good half-tone pictures, the quality of a phototypesetter is required.

Photographic copies

Photographic copies have the highest hard copy quality. The chemical constitution of film and paper gives the limits for resolution.

Plotters

A plotter works with one or more exchangeable pens that draw lines, graphs, diagrams, drawings, or pictures in ink in several colours directly on paper or film in different formats. The resolution is normally 50-100 dots per inch. The highest known resolution produced by a plotter is 300 dots per inch. In a flat bed plotter the paper is placed on a plane surface. The prints can often be carried out in large formats. Professional graphic reproduction systems sometimes use so called laser plotters with the possibility of exposing both film and plates in large formats and high resolution, like 2,000 lines per inch.

Telefax

The telefax is used to send text and image information via the telephone network. The area of the paper is often divided into

approximately 2 million pixels: 50 dots per inch horizontally and 90-385 dots per inch vertically. The very best resolution divides an A4-paper into 6 million pixels. It is common that telefax machines work thermally with heat sensitive paper in rolls of approximately 100 meters. There are, however, also fax machines built on laser printers. Many telefax machines can be connected to personal computers and then can be used both as scanners and printers.

Thermal printers

Thermal printers print dot matrix characters. A font is equipped with small needles. These point to an especially prepared, heat-sensitive paper. The needles are heated in a pattern that corresponds to the character to be printed, and the heat-sensitive paper is affected. Thermal printers often have a resolution of 200 dots per inch. To create colour pictures, foils with yellow, magenta, and cyan colour are used. By combining these foils a great number of colours can be produced. In desktop systems the number of colours is 256. In this system the colour is heated over to the image paper point by point. There are also thermal printers that heat up small ampoules inside a special paper so that the colour spreads inside the paper.

Telephoto

Telephoto or photo fax is a special kind of telefax equipment used for sending and receiving pictures in a full grey scale. There is also a system for colour pictures that transmits the pictures colour-separated. The transmission is done over the radio or the telephone network. Telephoto pictures are mostly used by newspapers and by some television stations. A thermal printer can be used to print the pictures.

Printing

Printing is the process of producing multiple copies of an original using a printing press. A printing press consists of some means for feeding the paper (or some other material) in contact with an inked image carrier and a system for delivering of the copies. There are four major categories of printing processes: relief, intaglio, the plano graphic process, and screen-printing. In all systems text and pictures are reversed in the printing forms that transfer the printing ink onto the paper, where it appears in the correct position.

Relief printing

In relief printing the printing areas are raised above the non-printing areas, and the impression is made directly from the inked raised surface to the paper. There are several relief printing technologies: woodcut, wood engraving, letterpress, and flexography.

Woodcut

The image is cut in a plate of wood, a wood block, which transfers the printing ink to the paper. It is very hard to produce text in small fonts on a plate of wood. The lines in the picture are often rough. The woodcut is the oldest form of printmaking. It can be traced back to ancient Egypt, Babylonia, and China, where wooden stamps were used to make decorative patterns or symbols in wax or clay. Blocks may have been used to print textiles in India as early as 400 B.C. The oldest book, "The Diamond Sutra," was block printed in 868 in China.

In Europe woodcuts were used for illustrating books as early as 1460 and became very important when the art of print-

ing expanded. During the 18th century artists in Japan produced woodcuts in colour in a masterly way.

In linocut the artist use a plate of lino instead of wood. Today graphic artists mainly use these methods as fine arts techniques.

Wood engraving

In wood engraving, also called xylography, the artist engraves the image in the cross-end of hard timber. This method was invented in England 1775 and became very important for the production of illustrated newspapers during the 19th century. To be able to prolong the life of the wood engravings, casts in metal, stereotypes, were produced during the middle of the 19th century. Today graphic artists mainly use this method as a fine arts technique.

Letterpress

In the letterpress process the image carriers can be cast-metal type, etched-metal plates, or photopolymer plates on which the image or printing areas are raised and the non-image areas are below the surface of the printing areas. In the production of books photo-engravings used to be very common for the printing of illustrations. Photoengraving was first done in 1824. The screen principle was introduced in 1852. The first successful process-colour engraving was done in 1893.

There are two kinds of photo-engravings: half-tone block and line cut. A half-tone picture is photographed in a reproduction camera using a raster to create a raster-image. The raster-image is copied to a photosensitive plate of zinc. The plate is etched resulting in a relief. Prior to printing the plate is

mounted in the printing form. There are several kinds of letterpress printing machines, both sheet-fed and web-fed presses. Presses include the platen press, the flatbed cylinder press, and the rotary press.

Flexography
In flexography rubber or plastic plates on cylinders are used. Low costs and solvent inks to speed ink drying are making inroads into book printing, magazines, and even newspapers. Flexography is being used extensively in heat-transfer printing for textiles. It is also a method for production of packaging materials, labels, and wallpaper.

Intaglio
In intaglio, or gravure, the image areas are below the surface in "ditches," and ink is removed from the non-printing areas by the scraping action of a metal blade. There is several gravure printing technologies: copperplate engraving, steel-die, drypoint engraving, mezzotint, etching, aquatint engraving, gravure, and rotogravure printing.

Copperplate engraving
In engravings the image or design to be printed is cut directly into a metal surface by the engraver. In copperplate engraving the image is engraved in a plate of copper, which transfers the printing ink to the paper. The line is very distinct and ends in a fine point. The oldest copy of a copperplate engraving was printed 1446, but it is supposed that the technology existed already a hundred years earlier. Copperplate engravings were first used for book production in 1476. During the 17th century copperplate engraving became the most important method for

production of pictures in books. Today graphic artists mainly use this method as a fine arts technique.

Copperplate engraving was once a widely used illustration process, but it has generally been replaced by photoengraving. Steel-die engraving is still used extensively for printing money, stocks, postage stamp, and other high quality prints. Copper plates and steel-dies are produced manually, mechanically, or photo-mechanically.

Mezzotint

In mezzotint the entire surface of the copperplate is first covered with hundreds of small pricks. These are burnished and scraped to create light areas. Mezzotint was invented in the 17th century and was used extensively until the early 19th century. It was the only method by which the many nuances in oil paintings could be reproduced. Graphic artists mainly use this method as a fine arts technique.

Etching

The image is scratched in a flat print plate covered with a layer of an acid-resistant coating, like wax. When the plate is placed in an acid solution the lines are cut, or etched, into the metal. By varying the time for the etching process, it is possible to decide the thickness and blackness of the lines. An etched line has blunt endings. The method of etching has been known since 1523. Graphic artists mainly use this method as a fine arts technique.

Dry point etching

In dry point etching the artist works the copper plate with a fine point tool. The line in dry point engraving is soft and fluffy.

Graphic artists mainly use dry point etching as a fine arts technique.

Aquatint
Aquatint engraving is a type of etching specially used for areas with many shades and nuances. In tonal quality aquatint is similar to the wash effect of a watercolour drawing. Aquatint is often combined with other printing techniques, such as line etching. The method has been known since the 17th century. Graphic artists mainly use this method as a fine arts technique.

Gravure
Gravure was first developed in 1875. The printing surface is divided, by means of a screen, into a series of cells etched below the plate surface. The surface may be treated in various ways to produce cells of varying size and depth. Sheet-fed and web-fed presses may be used in gravure. Gravure printing gives good picture quality, but text is fluffy and ragged. Web-fed presses have the plate wrapped around a cylinder and they can operate at high speeds. They are called cylindrical, or rotary, presses. Such a printing process is called rotogravure and is extensively used for printing of weekly publications, catalogues, and brochures in large runs.

Plano graphic processes
In a pantographic process, or lithography, the image and non-image areas are on the same plane and are distinguished by making use of the principle that grease and water do not mix. There are two different pantographic printing processes: lithography and offset lithography.

Lithography

Originally all lithographs were printed from a flat, lithographic limestone on a flatbed press. The image is drawn on the flat surface of the stone with a greasy crayon, an oily wash, or with India ink. After a chemical treatment the parts of the stone without the image elements are susceptible to water. The printing ink is transferred to the paper from the surface with the image.

The Austrian author Alois Senefelder invented lithography in 1798, and it has been used for printing of lithographic art, but also posters, placards, cards, advertisements, etc. As early as in 1858, Jules Chéret (1836-1932) created his first lithographic coloured poster in a characteristic, sweeping style (Hardy, 1986). Ten years later, he returned to France after a seven-year-long stay in London, bringing modern English printing presses with him. Chéret started a mass production of posters on a large scale. Printing up to 10,000 posters per hour was realized, and at a very low cost. Chéret drew his posters directly on lithographic stones.

By 1834 specially treated zinc plates began to replace the heavy stones. The use of photomechanical metal plates in the early 1900s made the technique of hand transferring from stones obsolete. In the 1930s the deep-etch process was introduced. Today graphic artists mainly use the original method.

Offset lithography

In offset printing, text and images are copied to a photosensitive plate of zinc, plastic, or paper. In plate-making the image area is covered with ink that is grease-receptive, and the non-printing areas are made water-receptive. The plate is mounted on a ro-

tary press. During the printing water and printing ink are supplied by special rollers. The paper or other substrate picks up the impression of the image as the paper travels between the rubber-covered blanket cylinder and an impression cylinder. There are many kinds of offset printing machines, from small office printing machines to very large industrial printing machines. Sheet-fed and web-fed presses may be used. In large offset printing machines it is possible to print four colours directly in one combined process. Today offset printing is very common for printing of newspapers, books, and most kinds of graphical products.

Screen-printing

In screen-printing, or silk-screen-printing, the image is on a screen stencil on silk, plastic, or metal through which ink is forced to the paper. Screen-printing originated during the Middle Ages in the art of stencil printing of China and Japan. It was practiced with great delicacy and intricacy. Until the 20th century, screen-printing was a decorative and commercial medium, used to enhance fabrics, wallpaper, furnishings, and advertising. Screen-printing was introduced in the US about 1910.

In screen-printing the printing form is a fine-meshed screen, mounted over a frame. It was a hand process for many years, used for making signs, banners, posters, and personal greeting cards. In the 1950s techniques for making screen stencils photo mechanically were developed. The pores of the mesh are blocked by the stencil in the background or non-image areas, and left open in the areas to be printed. Ink is spread over the screen and pushed through the open mesh areas with a rubber- or plastic-bladed squeegee to produce a print. Screen-

printing can lay down the thickest ink film of any of the printing processes. Screen-printing is used for printing on paper, plastic, wood, metal, glass, foil, and textile fabrics. The method is used for printing of posters, placards, and advertisements of various kinds. Silk-screen-printing is also used for many other industrial applications, e.g., for printing of electronic circuit cards. Special equipment can be used for printing of labels on bottles.

In serigraphy the stencils are hand-cut by artists for the production of screen prints as a fine art, serigraphs. In transfer printing or decal printing the image is printed with silk-screen-printing on a paper, which is then used to transfer the image to T-shirts and other textiles.

Electro-press

Electro-press is a new method for printing, developed by Harris Graphics Corp. in the US in 1990. The system functions like a copying machine but it has “magnetic ink” instead of a coal-based powder. This gives a better print quality. A computer gives impulses to a number of diodes charging the drum. The charged ink is attracted to parts of the drum and it is possible to print single pages or sheets.

Copying

The development of copying machines in recent years has been remarkable. Modern zoom optics in combination with micro-electronics have given birth to small and handy copying machines that automatically reduce and enlarge, retaining good quality. Concurrent with simpler handling and better quality, the consumption of copies increases. The Swedish public ad-

ministration produces about three billion copies each year. In average that means 5,000 copies per public employee, which means approximately 25 copies per working day. The figure for the whole world must be enormous.

Xerography

Xerography is a dry copying process. The text or image to be copied is projected onto a drum so that an electrostatic discharge is conveyed where the drum is illuminated and stays where the image is black. After that the charged (non illuminated) surface attracts an ink (colour) powder. This is transferred to the paper or to the material onto which the image is to be transmitted. The ink powder is fixed on and inside the paper by heat and pressure.

Colour laser copier

In a colour laser copier a scanner "reads" the original picture and converts it into digital signals. The scanning resolution is often 400 dots per inch. The scanner reads the image four times, for magenta, yellow, cyan, and black. Then the digital information about the image can be processed and transmitted to the laser printer for production of colour copies. The picture elements form 8 x 8 pixel raster-dots. Each pixel may be printed with magenta, yellow, cyan, or black, or with combinations of those. In this case the printed copies can have 64 gradations per colour. A pixel can also be non-printed and thus have the colour of the paper. Here the print resolution is 400 dots per inch. Since the image is handled in digital form, it can be edited in many ways. For example, the image may be reduced, enlarged, stretched, or slanted. Individual colours can be changed. A pro-

jector can be used for making full-colour copies from 35mm slides—even negative film can be used.

Photography

When the film is exposed to light in a camera, the chemical composition of the film is changed. Polygon crystals of silver halogens are reduced to silver. The film is developed and fixed. The grains of the film, i.e., the "pixels of photography," are a few thousandths of a millimetre in size and different in shape. Different films have different light sensitivity and different granularity. Today there are film materials for many different purposes: from "normal daylight films" to films sensitive to infrared light, X-rays or other invisible radiations. Such special films are mostly used for research.

The film resolution may vary from 500,000 to several millions for each square inch. The theoretical upper limit is often put to 800 million grains for a square inch of film. By changing lenses or by using a lens with changeable focal distance the image area is changed. A camera can be aimed at a subject from different angles. At a low angle the subject is seen from below. At high angle the subject is seen from above. At normal angle the subject is on the same level as the camera. A telephoto lens includes a small section of the subject. A wide-angle lens includes a large section of the subject.

There have been many different formats for still photography with miniature formats, film discs, film cassettes, standard 35mm film, and several larger formats. The individual grains, pixels, are irregular and run into and partly cover each other. This is particularly true for colour film where the light-sensitive grains are formed in layers. The film's light-sensitive grains

cannot really be compared to a computer's regular pixels. However, it is generally accepted that the granularity of a slide with the "normal" standard 35-mm colour film corresponds to a resolution of eight to nine million pixels. Using film with higher sensibility the resolution may go up to 54 million pixels for a colour slide and 18 million for black-and-white film. The size of a projected photograph depends on:

- The size of the film-frame.
- The quality of the film.
- The distance between the projector and the screen.
- The focal distance of the lens.

Apart from ordinary cameras there are several systems and different equipment for producing slides. Both Polaroid and Kodak have developed a series of hoods to be put in front of video and computer screens to take photos with direct films. After a minute or so the slide is ready to use. Many other systems work essentially as reversed scanners. A laser beam exposes the film dot by dot. The film is handled in a traditional camera body.

Several camera manufacturers have digital cameras that store photographs on a small magnetic memory card. The photographs can be stored in a computer and printed.

Film

By showing a sequence of pictures describing a course of events so quickly that the eye cannot discern the individual pictures, the brain experiences movement. As early as the beginning of the 20th century, different toys with animated cartoons were experienced as "live" by the amazed audience. Often film is re-

corded and shown with 24 frames per second. Faster recording and projection gives a more stable picture.

Film can also be projected with a different image frequency than that with which it was recorded. Recording with high frequency and projection with normal frequency results in slow motion. This is used for studies of fast or very fast and complicated courses of events, for example, a bullet leaving a rifle. Recording with low frequency and projection with normal frequency results in the opposite; fast motion. This is used for studies of slow or very slow courses of events, for example, a bud developing into a flower.

There have been many different kinds of film formats. Examples are standard 8mm film, S-8mm film, 16mm film, 35mm film, and 70mm film. Usually "standard film" refers to 35-mm film for movie production. The height-width relationship of this 35-mm film is 1:1.33. At the middle of the screen the resolution is some 450 dots per square inch. There are several types of wide-film-formats. Vistavision, CinemaScope, Cinerama, UltraVision, IMAX, OMAX and Showscan will be briefly mentioned here.

Vistavision is a system for wide-film using standard 35-mm film in a different height-width relationship. In America 1:1.66 is used and in Europe 1:1.85. Vistavision has a resolution of c 150 pixels per square inch in the middle of the screen.

CinemaScope is a system for wide-film first used in 1953. CinemaScope uses a special camera in which the "anamorph" optics "crowds" the image from the sides so that it fits onto a normal 35-mm film. When projecting the film a special projector "spreads out" the image again. The projected picture has the height-width relationship of 1:2,35. The screen is slightly curved

to get the whole picture in focus. In the middle of the screen the resolution is 200 pixels per square inch.

Cinerama is a system for wide-film first used in 1952. Cinerama uses three separate 35-mm films simultaneously. Three different cameras carefully put together record these. The films are projected on a wide, curved screen by three projectors. The viewers' angle is 70-80 degrees compared to 40 degrees for 35-mm film. Cinerama uses many speakers and stereo sound. In Disneyland a screen completely surrounding the standing audience was used for the first time in 1955. To start with eleven 16-mm film projectors were used. Nine 35-mm film projectors later replaced these. Simpler, semi-circular screens, “Cinema 180,” are now common in amusement parks in many countries. Cinerama films often show car hunts and dangerous rides in airplanes, helicopters, boats, trains and the like. The result is often very suggestive. The audience is easily carried away. The audio-visual stimulus is so overwhelming that the balance system is greatly affected. It is not unusual that spectators lose their balance and fall over. Audience standing up reinforces the suggestive effect.

UltraVision used special cinemas, built between 1966 and 1974. UltraVision was projected on a curved screen, where 70-mm film copied from 65-mm negatives was used. In the middle of the screen the resolution is 625 pixels per square inch.

IMAX and *OMAX* are wide-films giving very large picture areas. The film-frames are put “lengthwise” on a 70-mm film and not “crosswise” as on normal 35-mm film. OMAX or Omnimax is shown inside a dome. IMAX is projected onto a large flat screen. Cinema-U, a modification of OMAX, has one of the world's largest cinema screens 23 x 16 m, 368 m^2 (1:1.44) and

was used by the Japanese company Shueisha (Shogakan) at Tsukuba Expo '85. Here the film-frames were ten times as large as in normal 35-mm film, which gives a very impressive quality. The enlargement was 200,000 times. Another system with large high definition pictures is Todd-AO-70.

Showscan also uses 70-mm film and is also projected on a curved, very large screen, but is projected with 60 pictures per second. The fast projection and the six-channel sound, makes it possible to produce very realistic fast courses of events, like car hunts, etc. As in IMAX and OMAX the audience sits high up in a slanting auditorium, with a shorter distance to the screen. The system is overwhelming also because of the large screen, which goes all the way from the floor to the ceiling. At Expo '85 the screen was 24 x 11 m, 264 m^2. In the middle of the auditorium the viewers have the ultimate angle of 75 degrees horizontally. It is not possible to see the whole picture without turning one's head. It is possible to look straight ahead, up and down and to the sides that is considerably much better then to look up as in normal cinemas for standard 35-mm film. The resolution in Showscan is ten times as good as in conventional television.

Television and video

The word “television” comes from the Greek word téle, distant, and from the Latin word vidére, to see. Television, or TV, is a tele technical system for transmission of sound and images, stills, as well as motion pictures in both black and white and colour.

In an analogue television camera, the rays of light are projected from an image to an optical picture on a “picture plate” into the camera tube. By optic-electrical conversion the light

variations are transformed into a low-frequency image signal, a so-called video signal. A focused electron beam moving across the picture according to a set pattern scans the image on the picture plate, different brands working in different ways. Usually the picture is divided into picture elements by the electron beam moving in slightly inclined lines building up a so called television-raster. At transmission, the light information is transmitted from one picture element at a time. These are projected reversed on the television-receiver's picture tubes. The television-image is of course built up, or "put together," in the same way as it was divided into picture elements earlier. The inertia of the eye makes us perceive the different picture elements as individual whole images or as motion pictures.

Most Western European countries have agreed on a colour television-system called *PAL*, Phase Alteration Line. PAL is also used in Australia and in several countries in Africa and in the Middle East. 625 lines build up the television-image. Every line consists of a large amount of pixels. A colour television-receiver has a "shadow mask" with some 400,000 small holes for red, green, and blue, respectively. Our 50-periodical alternating current is used to produce 50 half images per second. In one pass, the electron gun of the television displays every odd-numbered line of the image from top to bottom. In a following pass, the electron gun creates the even lines. Each pass takes 1/50 of a second. This process is called interlacing. The two image halves "interlace" and we see only one image. A black and white television uses 450 effective lines with each 560 pixels. Thus, a black and white television-image consists of 235,200 pixels. Most video systems have considerably worse resolution than broad-

cast-television. VHS has, for example, usually 248 lines. Super VHS has an improved resolution of 400 lines.

In the US, Canada, and Japan a system called *NTSC* is used. NTSC, National Television Standard Committee, is both the name of the authority, which developed the American colour television-system, and of the system itself. The NTSC is an analogue system, which has been adapted over the years. First appearing in black and white in the 40's, then colour was added in 1953, and finally, stereo audio was added in 1982. NTSC uses 525 lines of resolution. In this system 60 half images are produced every second, and they are combined to 30 whole images per second.

France, Eastern Europe, the former Soviet Union, and Saudi Arabia use *SECAM*, Sequential Couleur à Mémoire. SECAM is so similar to PAL that it is possible to receive a SECAM-program in a PAL television-receiver, but the colour signals are produced in a different way. In a digital television or video camera there is a CCD-plate with normally more than 400,000 pixels.

The aspect ratio of these television standards is 4:3. This was a logical choice, since that was the aspect ratio of movie film at the time when television developed.

Television scholars are sensing a paradigmatic shift in the production, distribution and consumption of content including episodic programming (Christian, 2012) and news (Bondad-Brown et al., 2012).

There are several systems for printing television and video images on paper. Some video printers use thermal copying, others use plotters, and some employ ink-jet printers or laser printers.

Television-receivers

There are television-receivers in a number of types and sizes. The image size is measured diagonally in inches. The most common sizes are 18–27 inches for domestic use and 28–38 inches for public use. Here are a few examples of less common television-receivers:

Wrist-TV. In Japan a wrist-television manufactured by Seiko has been sold since 1985. The system consists of three parts: the actual wristwatch with a television-screen, a receiver to be carried in one's inner pocket, and a headset with an antenna. The image is created by liquid crystals containing 32,000 pixels. The size of the screen is only 17 x 25 mm.

Pocket-TV. The Japanese electronics company Matsushita in 1983 developed a very compact "pocket television" without a picture tube. The image is 2.4 inches diagonally and built up by liquid crystals. In August 1984 Seiko introduced a pocket colour-television. The image's diagonal is 2 inches. The set weighs 450 g. The screen consists of a thin film with a transistor in 52,800 individual pixels. The television-image has 32,000 pixels. During 1989 Philips introduced a battery operated 3" colour-television. The screen is built on LCD-technology and has 264 x 384, that is, 101,376 pixels.

Jumbotron. At Tsukuba Expo '85 in Japan, Sony had built the world's largest video screen, 25x40 m, i.e., 1,000 m^2. The image was very bright and more than 50,000 people could see it at the same time. The jumbotron image is built up by 150,000 pixels called Trini-lite, which are 80 x 45 mm. Every pixel consists of one blue, one red, and one green part. The jumbotron image is more than two million times larger than, for example, a wrist-television.

Multivision or *Video Wall* is a display system where many television-receivers (for example 16, 24, or 30) are put close together forming a check pattern. All screens can show the same image, different parts of the same image, or different images in varying configurations. Multivision is used at, for example, shows, exhibitions, and sometimes in department stores.

Third generation-television. VLSI (Very Large Scale Integration) chips control the image quality in every individual television-set. The television-station's analogue signal is transformed to digital signals, and they can then be processed in different ways. The image is cleared of shadows and noise, and its definition is improved. The picture can be zoomed in and "frozen." It is possible to produce prints of any still, simply by pressing the "print" button. A video printer produces the picture. Third generation television-systems might have a large, flat screen mounted on the wall with a possibility to open up several "windows" with different programs. It is not necessary to have an extra home computer for access to, for example, electronic shopping, home banking, and information retrieval in databases.

Compact video

Video 8 is a video system using a cassette with a 8mm videotape. Many systems have the cassette player built into the portable and battery-powered television-camera (CCD). No fewer than 127 electronics companies have agreed on a standard for "compact video." The cassettes are only slightly larger than a normal sound cassette. They are of surprisingly good quality and have a playing time of up to two hours. When recording, the cassette is inserted directly into the small camera. When playing

back, the camera is also used, connected to a television-set. Video 8 has all possibilities of finally ending the life of S-8 filming.

High definition television

The traditional PAL, NTSC, and SECAM television systems are all analogue. Analogue waves cannot be compressed to carry more data. In order to increase the quality of the image it is necessary to use digital data. These formats are called high definition television, HDTV. The aspect ratio of high definition television is 16:9. This ratio is similar to some current wide screen movies.

High definition television has a higher definition than today's analogue systems. There are a number of different formats for high definition television. The television-image is built up by 1,125 lines in Hi-Vision, by 525 lines in the NTSC system, and 625 in PAL. Each line in Hi-Vision has 1,000 pixels. To manage the high definition television-image's closer line construction, the bandwidth for each channel on the transmission side has to be increased to about 30 MHz. For conventional television a bandwidth of 6 MHz is sufficient. A capacity of 30 MB per second is needed to handle moving high definition television-images in a computer system. The committee, which documented the development of the digital standard, is called the Advanced Television Systems Committee, ATSC.

To do full justice to a high definition television, television-screens larger than normal, preferably one meter wide, are required. To be accepted by the normal consumer the television-picture tube must then be made flat so that it can be hung on the wall like a painting. Great research efforts have been made

in recent years to solve the problem of flat picture tubes. New techniques like liquid crystals and plasma picture tubes are being evaluated as well as new types of picture tubes and television-projection systems using new technology. Experiments with high definition television have been going on for a long time, with the latest research (mainly in Japan) aimed at digital systems, rather than the traditional analogue images.

Classification of visuals

A visual has a sender and a receiver, as can be seen in the communications models. A visual also has a content seen in the image. The visual is executed, e.g., as a drawing. It is structured or executed, e.g., according to size, shape, etc. The visual has a physical form, a format, e.g., as a 35 mm slide. The visual is used in a context, e.g., as an illustration in a textbook.

Classification systems

Visuals can be classified according to various criteria, such as sender, receiver, content, execution, context, and format, and even according to criteria such as function, use, and the means of production, etc. With reference to the distance to and size of the motif, photographers may classify pictures as long shots, full-length portraits, half-length portraits, and close-ups. In picture archives, pictures may be stored, e.g., according to content categories. Doblin (1980) classified iconographic (visual) information into categories:

- *Ideogrammatic* (symbols that attempt to convey a single meaning, such as a road sign).
- *Diagrammatic* (charts, graphs, or diagrams).
- *Isogrammatic* (photography, drawing, and drafting).

Hunter, Crismore, and Pearson (1987) presented a classification as points along a continuum from realistic to abstract:

- Photography.
- Artwork.
- Diagrams and maps.

- Graphics and formulae.
- Tables and charts.
- Orthography (icons).

Dewar (1999, p. 286) divided symbols into five main categories:

- Industrial and occupational (in the workplace).
- Representing methods (machines, instructions).
- Management of public places (transportation, museums, hospitals).
- Knowledge.
- Particular activities (sports).

For Wileman (1993, p. 12) all kinds of representations of an object are symbols. He provides a good illustration of different ways to represent an object and shows a continuum ranging from concrete to abstract.

The first group, *pictorial symbols*, includes photographs and illustrations or drawings. Viewers should easily be able to translate a pictorial symbol to a real-world example. The second group, *graphic symbols*, has image-related graphics, concept-related graphics, and arbitrary graphics. Image-related graphics can be characterized as silhouettes or profiles of the object. Concept-related graphics look like the object but have less detail than image-related graphics. Arbitrary graphics are abstract symbols for objects, constructed out of the designer's imagination. The third group, *verbal symbols*, is divided into two subgroups, verbal descriptions and nouns or labels. Only people who comprehend the language used to describe the objects can understand verbal symbols.

However, in my view there seems to be no major difference in "abstractness" between abstract arbitrary graphic symbols and verbal symbols (Pettersson, 2002b). Thus, I prefer to distinguish between two main categories of representations (I) figurative representations, and (II) non-figurative representations. Each category has two groups, and they have sub-groups. See the list below.

I. Figurative representations.

1. Visuals.
   - (a) Three-dimensional images.
   - (b) Photographs.
   - (c) Drawings.
   - (d) Schematic pictures
2. Graphic symbols.
   - (a) Pictorial symbols.
   - (b) Abstract symbols.
   - (c) Arbitrary symbols.

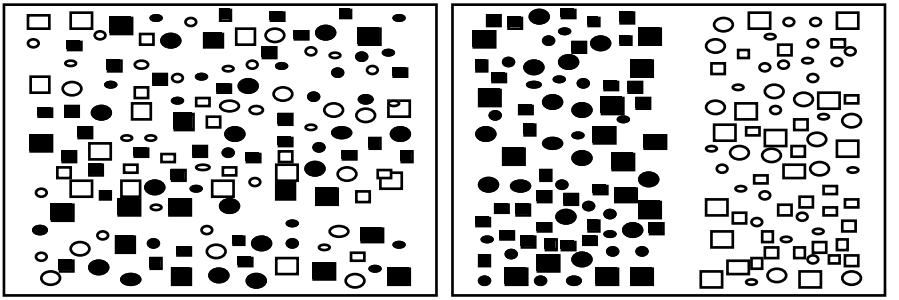
II. Non-figurative representations.

1. Verbal symbols.
   - (a) Verbal descriptions.
   - (b) Nouns or labels.
   - (c) Letters or characters.
2. Non-visual and non-verbal representations.
   - (a) Sounds.
   - (b) Odours and scents.

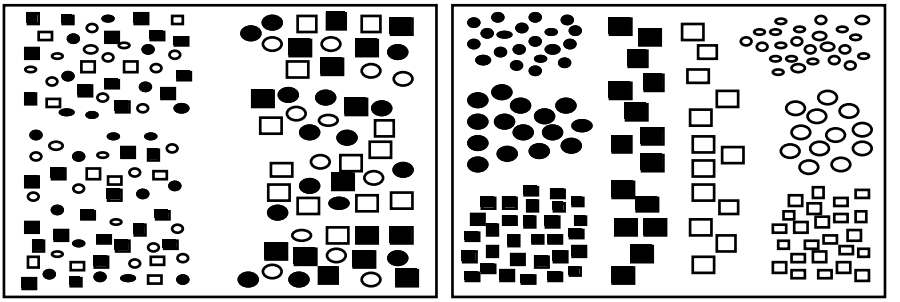
There are always many possibilities for classification of images. However, one and the same visual can and will be classified in different ways at the same time depending on the criteria ap-

plied. Often the borders between different groups partially overlap each other.

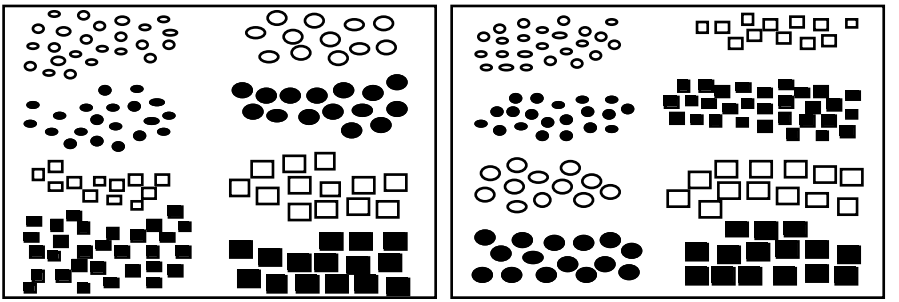
Below is an example of a classification exercise that demonstrates possibilities for classification in this case of 140 symbols, representing different types of information materials. These symbols are sorted several times according to different criteria. In this case each method of classification will produce the same eight groups of symbols.



Classification 1. The left picture shows 140 symbols, representing different types of information materials. They are distributed at random. There may be several ways to sort and classify the symbols. To the right the symbols are sorted once, according to colour.



Classification 2. Here, to the left the symbols are sorted once, according to size. To the right the symbols are sorted three times, according to 1) colour, 2) shape and 3) size.



Classification 3. To the left the symbols are sorted three times, according to 1) size, 2) shape and 3) colour. To the right the symbols are sorted three times, according to 1) shape, 2) size and 3) colour. Each method of classification will produce the same eight groups of symbols.

The picture circle

The “picture circle” is an attempt to provide a simple graphic description of the relationship between different types of pictures. The spot in the centre, the “bull’s eye,” represents *scribble*, which is the same all over the world and our first attempt to make pictures.

Increasingly advanced picture techniques have evolved from scribbling. This development can be represented with a series of concentric circles. Scribble is followed by handcrafted visuals. Drawings with a pencil, charcoal, crayons and pens; paintings in water colours, acrylics, oils etc., various textiles, simple flip over moving pictures, castings, models and sculptures of clay, plaster-of-Paris, wood, metal etc. are all examples. The borderline between hand crafted and technically crafted visuals is indistinct. Some picture techniques represent both handcrafted and technically crafted methods. “Hand-made” prints, linocuts, etchings, lithographs, serigraphs etc. are examples.

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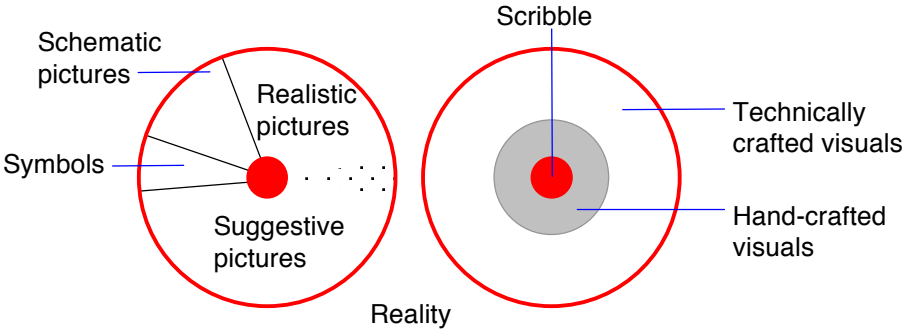


This is the picture circle. We have symbols, schematic pictures, realistic pictures, and suggestive pictures. The borderline between realistic and suggestive pictures is indistinct. Scribble (the dark spot) is followed by handcrafted visuals (grey) and technically crafted visuals. Visuals that are used in materials for information or instruction are very often schematic and/or realistic pictures.

Hand-crafted visuals such as a painting, drawing, diorama, or sculpture takes a long time to make, is highly personal, exists only in individual, unique copies, and only reaches a narrow public. Pictures made by children, for example, often display considerable spontaneity and reveal a great deal about their personality, degree of development, and maturity. In all hand-crafted pictures the relationship of information presented to reality is totally controlled by the artist. Most photographic pictures, though, are often records of an event or object that actually existed.

Technically crafted visuals can be made in a relatively brief period of time and easily reach a wide public. A TV camera can take live pictures viewed simultaneously by millions of people in different countries. In this way, we can “attend” various hap-

penings, such as sporting events, no matter where they occur. The ease with which news pictures can be produced and distributed may influence the selection of pictures. Sensational events, such as a disaster, may be assigned a relatively large amount of space in the mass media because pictures such as these attract widespread interest. Here, the mass media bear an enormous responsibility in their editing and selection of pictures.

Realistic pictures

Pictures are always related in some way to reality. But they must never be confused with reality and are incapable of replacing reality. However, in some situations people do actually confuse cyber-space with reality.

Objective documentation of a product, situation, or course of events by means of documentary drawings, electronic pictures, photographs, radiographs, satellite photographs, thermo graphic pictures, ultra sonograms and X-rays is often necessary. These pictures are frequently *realistic* and simulate reality in ways unique to each documentation process. However, apparently objective documentation can occasionally be extremely subjective and suggestive when the choice of images, the cropping, layout, and caption contents are overtly selective. The expression “the camera never lies” can often be very wrong indeed!

Handcrafted pictures are now easy to reproduce in newspapers, books, television, etc., but the technical reproduction processes do rob them of some of their original character. The halftone dots of the printing process or the special characteristics of electronic images are incapable of doing justice to, e.g., a

painting made with vivid colours and applied paint. This is even truer for sculptures, dioramas, and other three-dimensional pictures. Holograms, stereo, laser techniques and cyber-space may solve some of these problems and re-create a realistic perception of the third dimension. Current methods for making three-dimensional pictures require considerable development.

Suggestive pictures

The borderline between realistic and suggestive pictures is indistinct. Some visuals may be considered as suggestive pictures in one context but as realistic pictures in another context. Ambiguous pictures, which often express moods and emotions, are often referred to as *suggestive pictures*. Even here the creators of the pictures are out to influence the viewer in some way. Paintings often belong to this category. It is often difficult and sometimes impossible to make clear distinctions between different kinds of pictures. Advertising pictures, propaganda pictures, pictures for information or instruction, or educational pictures can be both ambiguous and unambiguous

Visuals that are used in materials for information or instruction are very often schematic and/or realistic. The role of such a picture is to convey a given piece of factual information in the simplest and most effective manner possible. But the picture may also have the task of conveying moods, or of arousing the viewer's interest and involvement by disseminating certain information.

The manner in which we perceive a picture and the efficiency with which the image communicates the image creator's intentions depend not only on the technical reproduction method chosen but also on the manner and presentation to a

large degree. We often need help and guidance in order to interpret a picture's message. Different captions or sound effects enable us to respond to one and the same picture in widely differing ways. This is especially true of moving pictures. The relative size of the picture, cropping, lighting, and the location on the cover of a book or newspaper page are also important to the way in which the picture is perceived by people with differing values, feelings, attitudes, experiences, background knowledge, and philosophy. Pictures often serve as amplifiers, i.e., the viewer often readily accepts information verifying his or her own opinion on a given issue.

Symbols

Pictures that affect us in an unambiguous way can be referred to as *symbols*. Signposts, traffic signs, labels, etc., belong to this category, representing objects or ideas. In specific areas symbols are a supplement to all languages to help create better and faster understanding. Functional, instructive graphic symbols are actually older than words. They are found in every culture however primitive. In specific areas symbols are a supplement to all languages to help create better and faster understanding. Symbols have evolved to the point of universal acceptance in such areas as music, mathematics, and many branches of science.

Some figurative graphic symbols are pictorial or representational (Pettersson, 1993). They are "image related" and simplified pictures. Pictorial symbols resemble the objects they represent. They can be characterized as silhouettes or profiles with no surface detail. A traffic sign with a silhouette of a locomotive,

to denote a railroad crossing, is an example of a pictorial symbol.

In the design process, some pictorial symbols may be successively simplified into figurative and abstract graphic symbols. They still look like the objects they represent but have less detail than pictorial symbols. In athletic contests, like the Olympic games, abstract graphic symbols are often used to denote the different sports. Good abstract graphic symbols are intuitive and we should be able to understand their meaning.

Some figurative symbols are arbitrary graphic symbols. They are invented and constructed out of the designer's imagination. Usually arbitrary graphic symbols have no resemblance at all to the objects or the ideas that they represent. Many are based on geometric shapes. Many signposts and traffic signs are often good examples of arbitrary symbols. They are unambiguous by convention. We agree and decide on their meaning. Just as new words have to be learned when we begin to study a new topic; we have to learn arbitrary graphic symbols. Many nonfigurative verbal symbols, written characters, and letters of various alphabets have evolved from simplified pictures. Verbal symbols are used in written languages and in many branches of science. In many areas, verbal symbols have reached universal acceptance.

Taking up only a very small amount of space, symbols can convey a message containing a large amount of varying information, equivalent to one or more sentences of text. Image perception is very rapid, virtually “instantaneous.” Reading and comprehending the equivalent message in words takes much more time. So symbols permit rapid reading. This is important in numerous situations, e.g., in traffic, industry, and aviation.

Read more about symbols in the book *Information Design 4– Graphic Design*.

Schematic pictures

In many situations we need to use *schematic pictures* such as blueprints, charts, engineering drawings, graphs, maps, etc. Schematic pictures are representations of reality, but they are often non-iconic and may lack any resemblance with reality.

Classification of schematic pictures

There are several ways to classify schematic pictures. We can study how schematic pictures are executed, how and when they are used, and of what the content consists. The following pages provide an attempt to classify schematic pictures with respect to their type of illustration and their purpose.

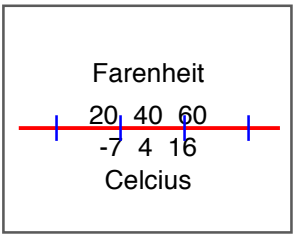
1. Word visuals have words and/or figures and digits. There are four basic groups of word visuals.

1. Words, verbal summaries, headlines, lists, quick facts, quotations
2. Tables
3. Word visuals with pictograms
4. Word visuals with pictures

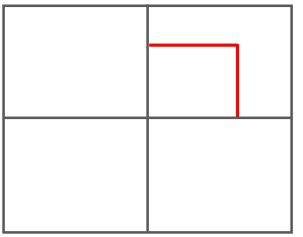
2. Graphs are pictorial representations of numerical data or a geometric relationship between quantities. The graph of an equation shows pictorially the relation of independent variables to dependent variables. When a variable y is a mathematical function of another variable x, then the pictorial graph of that

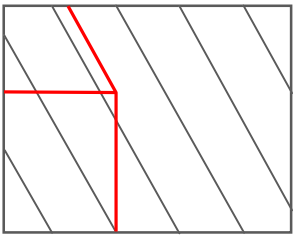
function will represent the locus of all points (x, y) that satisfy the specific relationship. The line representing the relationship between or among variables on a graph is called a curve, even when it is straight. There are many kinds of graphs:

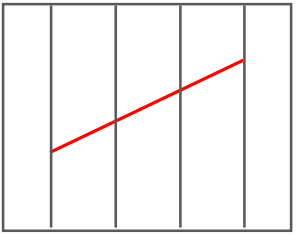
1. Single scale
2. Coordinate grid
3. Nomogram
   - Abac
   - Alignment chart
4. Straight line graph
5. Normal curve
6. Exponential curve
7. Cumulative curve
8. Multiple line graph
9. Segmented graph, stacked curves, or stacked area graph
10. Scattergram, scatter plot, scatter graph, or scatter plot graph
11. Frequency polygon
12. Multiple frequency polygons
13. Histogram and multiple histograms

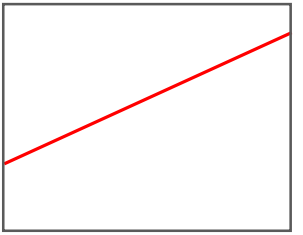


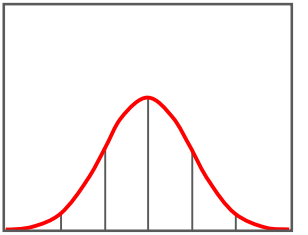
Single scales

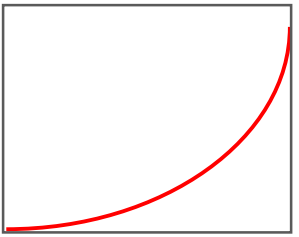

Coordinate grid

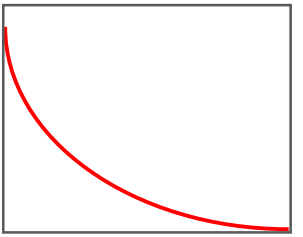

Abac

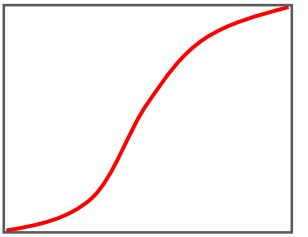

Alignment chart

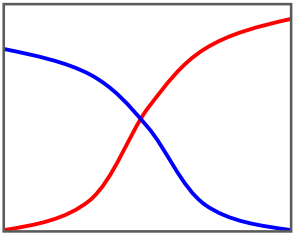

Straight line

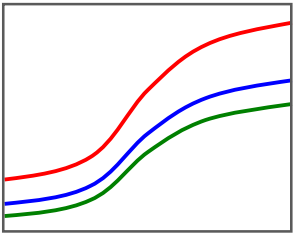

Normal curve

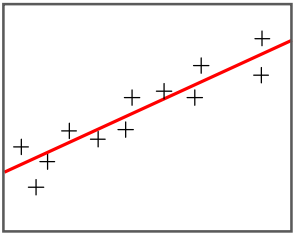

Exponential curve

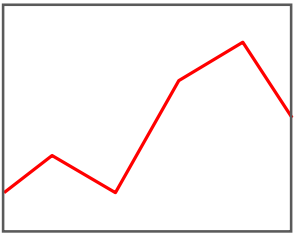

Exponential curve

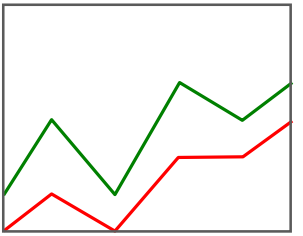

Cumulative curve

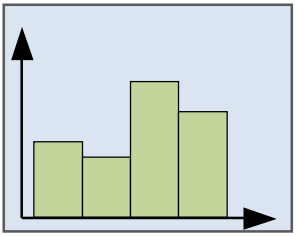

Multiple line graph


Stacked curves


Scattergram


Frequency polygon

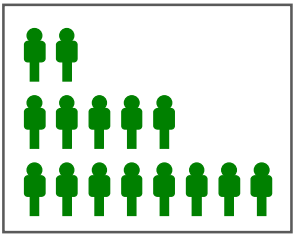

Multiple freq. polygons

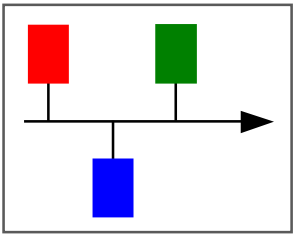

Histogram

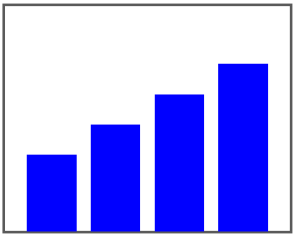
3. Diagrams are illustrations that systematically show the relationship between various factors. It is far too easy to make diagrams confusing, difficult to understand, and misleading. Diagrams need to be correct and simple. There are many kinds of diagrams:

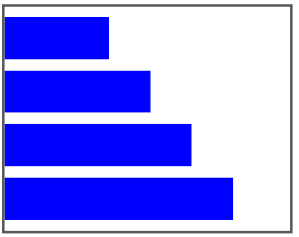
1. Pictograph or isotype system chart, each icon represents a given quantity
2. Line diagram, e.g., a "time line"
3. Bar charts
   - Vertical bar chart or column chart
   - Horizontal bar chart
   - Stacked bars
   - Segmented bars
   - Clustered bars or multiple bars
   - Overlapping bars
   - High-low bars
   - High-low close bars
   - Enhanced high low bars
4. Pictorial length chart with comparison of lengths
5. Tri-linear chart
6. Pictorial area chart with comparison of areas
7. Polygon chart
8. Circle chart with comparison of areas
9. Pie charts (or circle graphs)
   - Pie chart
   - Segmented pie chart (or exploded pie chart)
   - Polar area diagram
   - Wind rose chart
   - Ring chart of disk (or multilevel pie chart)

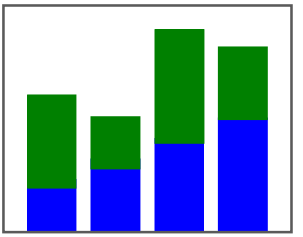
10. Parallelepipeds
11. Segmented volumes
12. Spheres, comparison of volumes
13. Surface chart
14. Pictorial characters in space
15. Metroglyph chart
16. Bubble chart
17. Kite chart
18. Block diagram
19. Four-field diagram
20. Quantity diagrams, totality and subsets
21. Tree diagram, organizational and hierarchical structures
22. Flow diagram or flow chart
23. Web diagram, planning and production
24. Circulation diagram
25. Circuit diagram
26. Pictodiagram
27. Transportation diagram

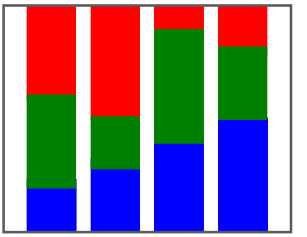

Pictograph

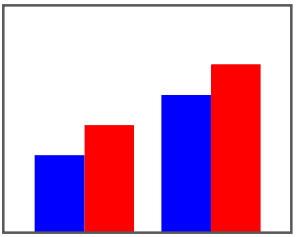

Line diagram

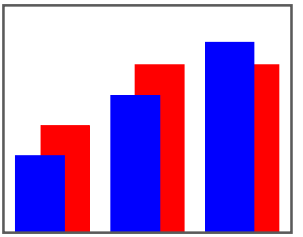

Vertical bar chart

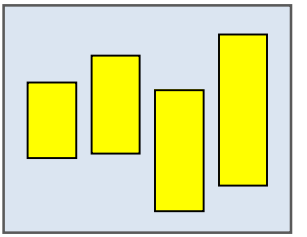

Horizontal bar chart

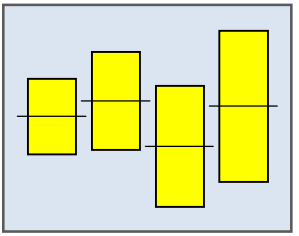

Stacked bars

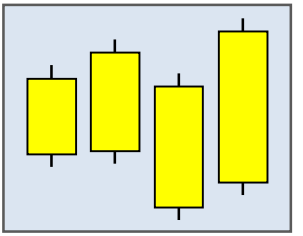

Segmented bars

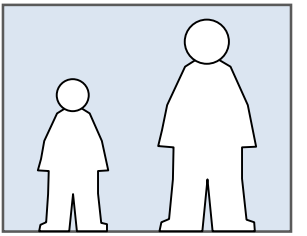

Clustered bars

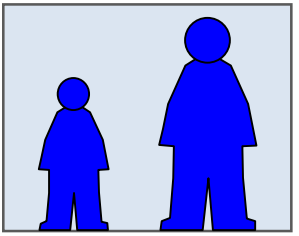

Overlapping bars


High-low bars


Hi-lo close bars


Enhanced hi-lo bars


Pictorial chart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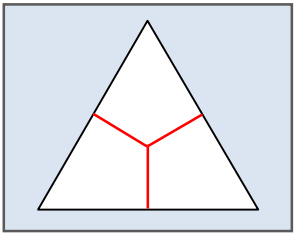
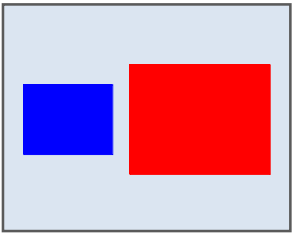
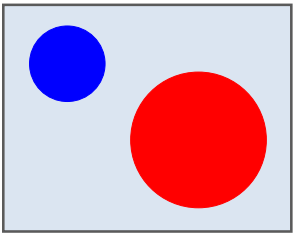
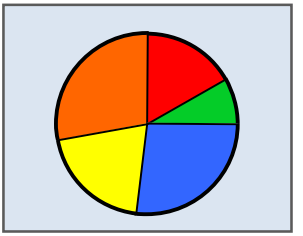

Tri-linear chart

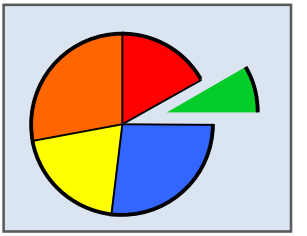

Polygon chart



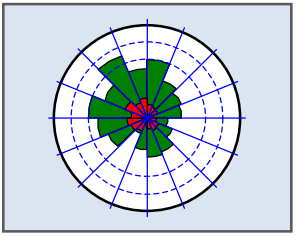
Circle chart



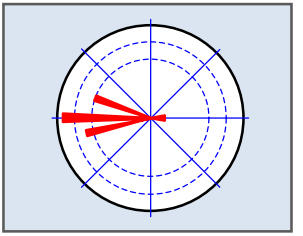
Segm. circle chart



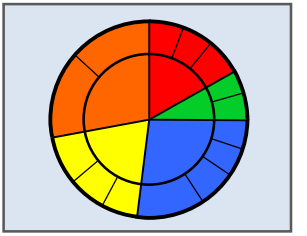
Segm. pie chart



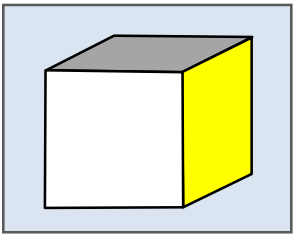
Polar area diagram



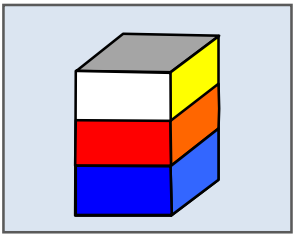
Wind rose diagram



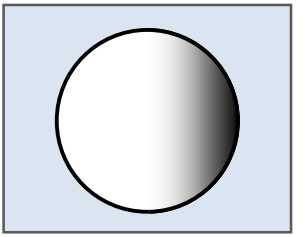
Ring chart of disk



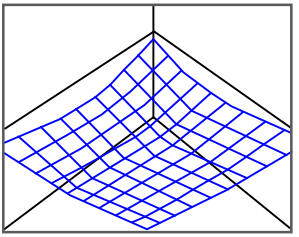
Parallepiped



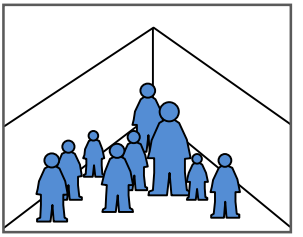
Segmented volume



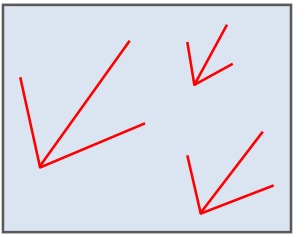
Sphere



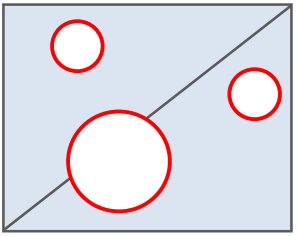
Surface chart



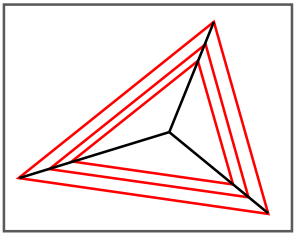
Pictorial characters



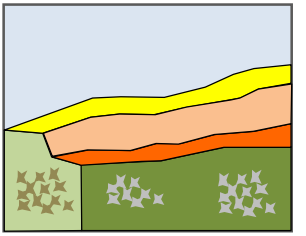
Metroglyph chart



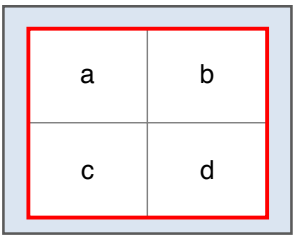
Bubble chart



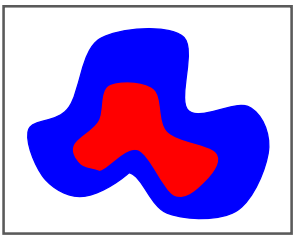
Kite chart



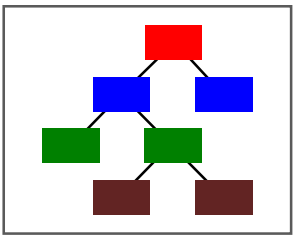
Block diagram



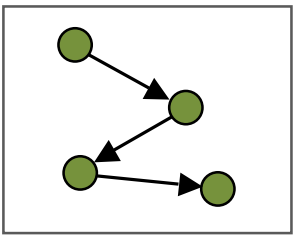
Four field diagram



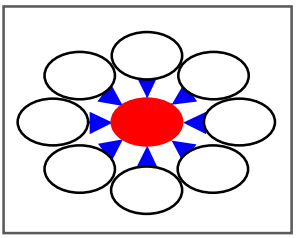
Quantity diagram



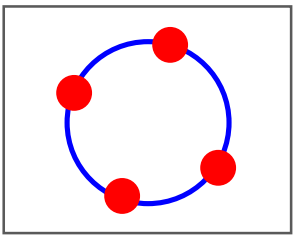
Tree diagram



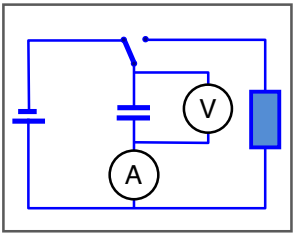
Flow diagram



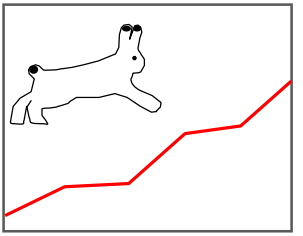
Web diagram



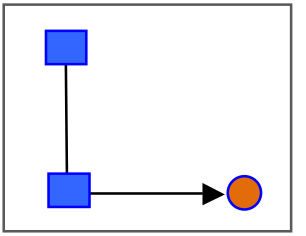
Circulation diagram



Circuit diagram



Pictodiagram



Transport diagram

4. Matrices are mathematical quantities consisting of rectangular arrays of numbers.

1. Four-field matrices
2. Multiple field matrices
3. Complex matrices

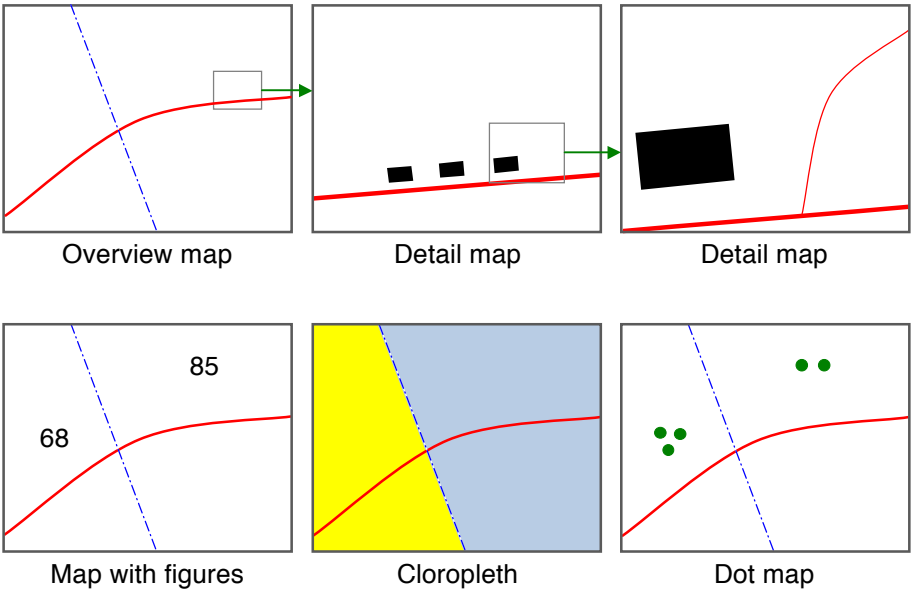
5. Plans show plans for various constructions and systems

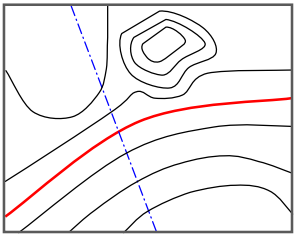
1. Construction drawings
2. Floor plans and layouts

6. Maps are heavily reduced flat images of the surface of the earth. A map enables the user to see a generally complete representation of the world at one time. Mapmaking, or cartography, attempts to reproduce portions of the earth with a minimum of distortion. The International Cartographic Association defined *cartography* as "the discipline dealing with art, science and technology of making and using maps" (ICA, 2012). The information contained in a map should be as accurate as possible. The scale of a map is the relationship between a distance on the map and the corresponding real distance. Theoretically, an infinite variety of map types exists. Most of the commonly used map types are either cultural or physical in nature. Common types of maps are distributional maps, geologic maps, soil maps, land-use maps, economic maps, zoological and botanical maps, statistical maps, political maps, topographic maps, meteorological maps, transportation maps, and historical maps. Map projections can be placed in one of three general groups, based on the method in which the information on the round earth is transferred to the flat map. These are azimuthally, conic

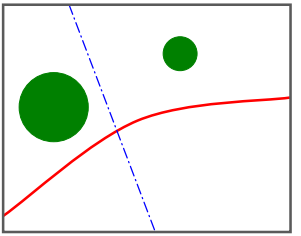
and cylindrical projections. The following examples are based on the contents in maps.

1. Overview or location maps
2. Detail maps
3. Map with figures
4. Cloropleths
5. Dot maps
6. Isopleths
7. Circle chart maps
8. Pie chart maps
9. Bar chart maps
10. Flow maps

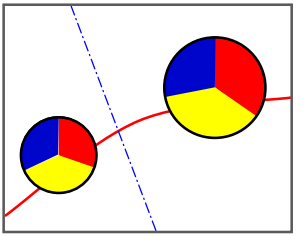




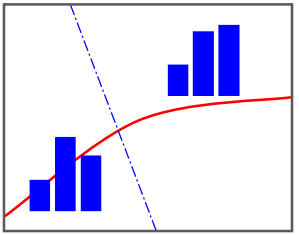
Isopleth



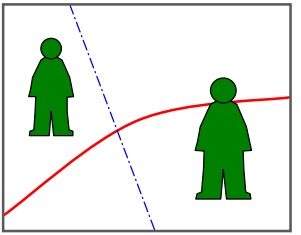
Circle chart map



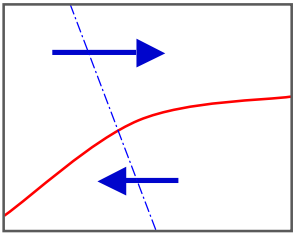
Pie chart map



Bar chart map



Pictorial chart map



Flow map

7. Metaphorical pictures are used for something that has a similarity with the actual image contents. Some examples are mentioned here.

1. Staircase leading to a target
2. Pieces in a jigsaw puzzle
3. Concentric circles around a centre
4. Circulations
5. Spirals showing circular continuity

8. Drawings may be created in many artistic styles. The purpose of schematic drawings is basically to inform, not to decorate. Schematic drawings must not be excessively imaginative or unnecessarily abstract. Clarity is the most important factor. Important types of drawings are:

1. Stylized drawings
2. Sketches
3. Diagrammatic renderings
4. Informative drawings, figures and objects
5. Analytical drawings working in concert with photographs
6. Cross sections
7. Exploded drawings
8. Cut-away drawings
9. Panoramas
10. Silhouettes
11. Cartoons
12. Comic strip sequences

9. Integrating text and pictures with the use of captions, headings, explanatory texts, and labels.
10. Integrating drawings and photographs makes it possible to combine the advantages from both categories. Photographs are documentary and drawings can be analytical.

Use of schematic pictures

Within one R&D-company most people created their own schematic pictures in most of their documents (Pettersson, 1993). The quality of the pictures reached from "very good" to "very poor." Several people designed their own graphic symbols, which they used in various combinations in their schematic illustrations. A sample of documents used no less than 29 different schematic pictures of telephones. Some of these pictures were well-drawn schematic pictures, some were pictorial symbols, and some were abstract symbols.

This variety of symbols and image elements used in schematic pictures makes it hard for readers to understand the mes-

sages. The variety is often not aesthetically pleasing. It does not aid comprehension; rather it introduces a lot of confusion. Technical documentation must be easy to comprehend. Thus it is important to be consistent and to use the same symbols in different schematic pictures.

Creation of schematic pictures

A "terminology council" was responsible for the development of the new terminology that was needed in the company. Since symbols can be regarded as "iconic or figurative representations of concepts," a set of carefully defined symbols was created as image elements. These symbols were stored in digital form, and could easily be accessed from all workstations in the network. We had written "guidelines" to make it easier for people to create their own schematic pictures.

The new images can be stored in a database and be used in different documents, such as memos, instructions, reports, magazines, and even books. Images can also be used in other media, such as computers, OH-transparencies, slides, and multimedia. Since the formats are different, images must be adopted for each medium (Pettersson, 1993).

Using standard image elements and standard symbols in schematic pictures is very cost-effective, and makes it far easier for all readers to understand the intended messages. The readability of schematic pictures is increased.

Descriptive visualization

Martin (1989) defined technical illustration as (p. 6): "illustration of man-made materials, objects and constructions, possibly including the situations in which they are used and the processes and systems in which they are incorporated." The main

purpose of a technical illustration is to describe or explain these objects and constructions to a more or less non-technical audience. At one end of a scale, the technical illustrator is asked to produce a picture that is completely accurate, to the point where someone can physically construct an object by reference to the technical illustration. At the other end of the same scale the purpose of the technical illustration is to provide a general impression of what a specific object is or what it is used for in order to improve the viewer's understanding.

Descriptive visualization of objects and systems has been an important aspect of technological development since the beginning of the industrial revolution. A technical illustration can always supplement a verbal explanation, and may sometimes replace the words. Martin (1989) pointed out that clear visual instruction on individual components and their assembly sequence was of crucial practical importance during World War II, when technical illustrations enabled unskilled workers to play an efficient part in manufacturing, replacing the trained workforce which was depleted by conscription to the armed forces. Descriptive visualization of objects and systems are also used in medicine and natural history, or scientific illustration. Another specialized subject area is architectural illustration.

Photographic portrayals

An analysis of a photographic portrayal can examine positive versus negative depictions of individuals in photographs (Archer et al 1983, Moriarty & Popovich, 1991, Moriarty and Garramone 1986, Wanta and Chang 2000). These authors have examined several variables that will influence our perception of individuals in photographs.

- *Camera angle*. An individual appears powerful if he or she is photographed from below with the photographer looking up at the subject. An individual appears less powerful if he or she is photographed from above (Moriarty & Popovich, 1991).
- *Camera placement*. Photographs showing a subject straight on are more positive than those showing a subject from the side and much more positive than those showing a person from behind (Moriarty & Popovich, 1991).
- *Eyes*. Individuals shown with closed eyes are viewed more negatively than those shown with open eyes (Moriarty & Popovich, 1991).
- *Facial expression*. Individuals smiling are viewed as positive and individuals frowning are viewed as negative (Moriarty & Popovich, 1991).
- *Framing*. The larger a person's face appears in a picture, the more positively our perception of that individual is. A close-up headshot of a person is more positive than a photo taken from a distance (Archer et al. 1983).
- *Head position*. Individuals looking straight at a camera look more in control than those individuals looking up or to the side. Individuals look least in control if they are looking down (Moriarty & Popovich, 1991).
- *Posture*. Individuals are viewed more positively if they are shown walking, running or moving. People standing are viewed more positively than if they are motionless (Moriarty & Popovich, 1991).

- *Purpose of photo*. The purpose of a photo is important for our perception of the person depicted (Moriarty & Garramone, 1986).
- *Secondary subjects*. Other people in a photograph, the context of the individual, may influence how people view a photograph (Wanta, 2000).

Archives and image databases

Pictures are now being created more rapidly than at any time in history. Millions of pictures are produced every day. Sweden alone (with a population of nine million) accounts for more than 200 million amateur photographs each year. And each of the country's 2,000 professional photographers produces a half million photographs before retiring. Many pictures are put to active use in various ways. But a large portion ends up in collections. Some collections evolve into archives. There are four main types of archives:

- Personal, private collections
- Commercial photo agencies
- (Personal) research archives in different fields
- Collections in museums and other public institutions

Greenwood (2011, p. 85) noted that the compartmentalized nature of formal organizations can make it difficult for people from different areas to collaborate and participate in decision-making regarding photo archives.

The contents of an archive of photos can help explain how others live, can illuminate the convictions of a community, and can document processes and procedures. Perlman (2011) reported on the photo archives of a kibbutz in the north of Israel.

She observed (p 9.): “the photographs kept in the archive seemed to have the potential of turning images into unshakable myths in the eyes of the beholder.”

Bunn (2013) studied the archives at the Asheville Community Theatre in the state of North Carolina, USA. She concluded that a well-organized, thoughtfully managed photo archive is an important part of an organization’s holdings. For a community-based organization, like Asheville Community Theatre, the photographs in the archives reflect the participants and their dedication to the art of theatre over the past seven decades. Archival photography is not only important in order to capture who was in a production, but also serves to accurately reflect the production’s design choices.

Simple indexing

Many photo collections are small enough to be accessed without any special index. The owner knows which pictures she or he has and where they are stored. This ease of access is no longer possible in large photo archives holding hundreds of thousand or even millions of photographs. So a large number of different indexing systems have been devised.

Pictures may be indexed according to category, motif, or subject. Era, geographic area, and persons may be other classification concepts. Accession and negative indices and information on the dates photographs were taken and copyright may also be provided. Commercial photo agencies often permit direct, manual, and visual perusal of originals or copies in each category. The feeling here is that the indexing or cataloguing of individual photographs takes too long, costs too much, and conveys no decisive advantages. Institutional photo archives, as

used in research and education, are often unable to manage without some kind of cataloguing. Many indexing systems are based on hierarchic classification of picture subjects according to some pre-determined code or on systematic catalogues in which every index word has a corresponding alphabetical or alpha-numerical designation.

Systematic catalogues

The *Inconclass system*, developed in Holland, has a systematic catalogue on theological subjects. The system is often used for classifying artistic pictures. Each picture can be assigned a classification comprising a few index words/codes. The method is based on a description of the picture's main subject. Picture details and minor subjects cannot be indexed.

Many museums use *Outline*, i.e. OCM (= Outline of Cultural Materials), for classifying pictures. Outline was designed to be a general classification and code system for social and cultural subjects and operates with computerized routines. However, finding codes (headings) that describe true picture contents is as hard with Outline as with Iconclass. So classification is influenced by the perceptions of the individuals doing the coding. This makes it difficult for a visitor to find pictures complying with her or his requirements. Similar results have been obtained with many systems in other countries.

The *Iconograhic Archives* in Uppsala, in Sweden, employ a system with a much finer “mesh.” Here, pictures with subjects in the field of ethnology and cultural history (e.g. ethnographic or folkloristic scenes) are recorded. The date a photograph was taken, its country of origin and the source are recorded for each picture. After an analysis of the picture contents, the main sub-

ject and minor subjects are then recorded according to a systematic code catalogue subdivided into subjects. The entry of search conditions combined in different ways results in fast computer extraction of information on whether the desired picture subject is on file.

Large picture archives

APIS (Agency and Photographer Information System), developed in the Federal German Republic, is a computerized system for managing picture archives and all the administration related to the lending of pictures and selling of rights. A serial number, heading number, a key word describing pictures contents, the photographer's name and the copyright holder are recorded for each picture. This information is printed on a label that also bears an optically legible bar code. The label is attached to the back of prints or to mounts of transparencies. All captions are stored in a database for full text searches. Desired photographic subjects can therefore be accessed very quickly.

We can file photographs in numeric order or by subject (heading). The latter system makes it possible to conduct manual, traditional searches. The barcode is read with a light pen for rapid entry of information on all pictures borrowed and returned. The system also supplies invoicing, bookkeeping, statistics, detailed reports to the photographer and other copyright holders etc. plus other administrative information.

Spectrum, the Dutch publisher of reference books, has developed an advanced system of databases for both text and picture administration (Thesaurus). The company indexed 45,000 illustrations, each accompanied by information on up to seven parameters. These pictures have been published at 90,000 loca-

tions in different reference books, in various sizes, with different cropping etc. The computer system contains all relevant information on the illustrators/photographers, copyright, costs, disbursements, archive locations of originals and films etc. The system offers several different ways of searching for pictures by means of search words. Spectrum experimented with models for image classification.

An image classification system makes sense only if different classifiers apply the same objective criteria to the image and subsequently different picture researchers are able to locate the same illustration. In a first experiment in 1979 twelve editors had to classify 25 pictures by using catch words. Results showed a correlation as low as 0.2. In a following experiment a questionnaire regarding categories combined with requests for description was used. In this case the correlation was 0.67. In the final system, 1983, all indexing was made in the computer with a calculated correlation of 0.80, which seems to be very good.

The development of WWW and Internet has opened new possibilities for storage of huge collections of images. Each of the stored documents can be quickly retrieved and displayed on a screen or printed as hard copy if desired.

Indexing systems

Image databases or image retrieval systems are computer-based systems for searching and retrieving images from a large database of digital images. Stanchev (1999) defined image databases as, "a logically coherent collection of images with some inherent meaning. The images usually belong to a specific application domain. An image database is designed, built, and

populated with images for a specific purpose and represents some aspects of the real world."

Image databases have many implications for society and are used in a wide variety of applications such as: anatomy, astronomy, automated catalogues in museums, biology, botany, computer aided design, criminal identification systems, cultural heritage, geographical information systems, geology, house furnishing design, industrial systems, manufacturing systems, medical image management systems, mineralogy, and multimedia libraries.

Retrieval systems for first-generation image databases included alphanumeric strings, full scripts, and keywords. Metadata required manual input. However, manual input is costly and there is always going to be a lack of coincidence between those who made the annotations and those who want to retrieve images.

A large number of indexing systems have been devised to guide access to individual images. However, real-life experience shows that it is often very hard to find the intended image. We know from several experiments that various subjects perceive images in many different ways (Pettersson, 1985, 1986b, 1986c). Even simple line drawings evoke many associations. Vogel, Dickson, and Lehman (1986) showed that image enhancement intended to improve interpretation of image content sometimes got in the way of the message. They concluded that image enhancement graphics should be used selectively and carefully. When in doubt, they recommended, plain text should be used.

Limburg (1987) pointed out that receivers have even more ambiguity or semantic diversity with visual images than with

most expressions of written language with its manifold meanings. Lodding (1983) reported on the problems with misinterpretations of icons used in computer systems. However, he concluded that people find naturalness in dealing with images either as an aid to or, in some circumstances, as the sole means of communicating.

A picture in a database can be sought with the aid of verbal and visual indices. Each picture has a picture number as a heading and a verbal description. The pictures can be listed systematically in numerical order in a numerical index. Or they can be listed in alphabetical order (according to their headings) in an alphabetical index.

Picture descriptions are stored in a free-text (or full-text) database, making it possible for users to access a picture via a number of different descriptive terms. A verbal description of a picture should be rather comprehensive. It may sometimes apply to an entire picture series. A database search based on certain descriptive terms could produce several different pictures with the same description. All such pictures would then be displayed in separate windows on the terminal screen. Entry of a command causes full-screen display of any of the windowed pictures. For children it might be easy to point with a finger at the window on the screen. Pictures can be stored in files, stored in other files in a kind of a tree structure. When a file containing pictures is opened, the file contents are displayed in windows that can be as small as 1.5 x 1.5 cm. Thus, verbal searches are used on higher levels and visual, iconic searches on lower levels in the storage structure. Users who know in which file a desired picture is resident can go straight to that file. Index searches are employed when the whereabouts of a given picture is unknown.

Batley (1988) experimented with retrieval of pictorial information from a database on a videodisc. The videodisc was created specifically for the experiment. It contained 950 photographs selected from a collection of 40,000 photographs by a Victorian photographer. The photographs were arranged into broad subject groupings such as: Cathedrals, Castles, and Rivers. A program in the authoring language Microtext provides access to the database. The program allows users to scan through images in the database using a joystick ("serendipitous browsing") step through groups of related photographs ("specific browsing") or type in key-word descriptors ("key-word search"). Summary files keep a record of each user's interaction with the database. Users may request text information about the photograph currently displayed on the screen and store a record of photographs they retrieve. The findings indicate that the search strategies adopted by users are dependent upon two factors: the nature of the information need and the individual user characteristics. Batley offers three proposals for the design of visual information systems:

1. Emphasis should be on providing a range of search options for the user–to accommodate both narrowly defined and exploratory searching and to accommodate individual user preferences.
2. Care must be taken in the design of the user interface–the emphasis should be on ease of use–so that the system is accessible to both naive and expert users.
3. Some attempt should be made to individualize searching–by allowing users the option of selecting their own range of scanning speeds, choosing between menu selection and typ-

ing commands, choosing which input devices to use, designing a screen layout, etc.

In the late 1980's and early 1990's retrieval systems were able to compare image contents, based on colour, shape and texture (Furt and Marques, 2002). So far, these systems have very limited capabilities and are being employed in industrial robots programmed for taking certain components from a conveyer belt and creating assemblies with other components. Developments are most advanced in the military sector, e.g., in target-seeking missiles capable of reading terrain and comparing readings to a pre-programmed map and a predetermined route to the target (e.g., the Tomahawk cruise missiles used in the Persian Gulf War). But there is yet another major, unsolved problem, since one and the same structure may occur in different pictures. Empirical studies (Pettersson 1987) have shown that subjects given a number of image elements combine them to form many different picture contents. A lot of research on retrieval systems is still needed.

Style

An illustration is a picture complementing words in a verbal and visual presentation. Illustrations are printed in lexi-visual presentations. In audio-visual and multi-visual presentations illustrations may have many other formats. Illustrations are a "sub-set" of all visuals. Sloan (1971) discussed four pictorial artistic styles, 1) photographic, 2) representational, 2) expressionistic, and 4) cartoon. Photographic style was defined as a coloured photograph of the subject. Representational style was defined as an artist's rendition of the subject that conforms to

the subject in its true form. Expressionistic style was defined as an artist's rendition of the subject that leans heavily towards abstraction. Cartoon style was defined as an animated caricature of the subject. These four artistic styles form a realistic to an abstract continuum.

Dondis (1973) discussed the anatomy of a visual message. We express and receive visual messages on three levels; 1) representational, 2) symbolical, and 3) abstract. Representational forms of illustrations are actual photographs of things. In symbolical forms pictures show one thing and connote another. In abstract forms illustrations provide minimal visual information on the phenomenon illustrated.

In addition to size, shape, colour etc, the way pictures are shot is important. The aesthetic value of a long shot is different from that of a medium shot or close-up. According to Zettl (1990) a scene can be presented 1) objectively (usually a long shot), 2) subjectively (usually a close-up), or 3) creatively (created by the medium itself, for example, superimposition, picture montage, etc.). Metallinos (1990) has developed a schema that explains these three forms of picture presentations in accordance with their functional aesthetic value. We can 1) remain totally objective and look at an event, 2) become subjectively involved and look into an event, and 3) where the event is totally dependent on the medium for its existence we can create an event.

An important difference between main categories of pictures is the use of light. All pictures printed in books, magazines, papers and other printed matter, and textiles, are seen in the normal directed lighting. In TV- and computer screens the light comes through the image. Films, slides and overhead

transparencies are often projected on a screen. The difference in nature of these groups of pictures is important to study. It is possible to organize or classify pictures according to their format. Depending on the execution illustrations can be divided in three main categories: 1) art work, 2) photographs and 3) technically crafted visuals.

1. Artwork

Artwork is a metaphor, an abstraction, a manipulated and constructed image. It can look like reality, but it is always a representation. Artwork abstracts, eliminates details, focus attention and communicate fast. It consists of cartoons, line art, realistic drawings, schematic drawings, stylized drawings, drawings of animate objects, drawing of inanimate objects, exploded views, X-ray drawing, blueprints, panorama drawings, paintings and others.

2. Photographic pictures

Photographic pictures are often quite realistic records of an event or object that actually existed, like product photos, portraits, situation photos, landscapes etc. Photography has got a sense of reality and a genuineness that makes it powerful. Most people believe their eyes, and when they see photos it appears real to them. A photograph can look like reality, but it is always a representation.

3. Technically crafted visuals

Technically crafted visuals may be computer generated maps (plotting maps, detailed maps, figurative maps, cartograms), diagrams (bar diagrams, linear diagrams, pie charts, block diagrams, pictograms), scales (time scales, distance scales, size

scales), charts (flow charts, organizational charts). Technically crafted visuals are also produced with TV cameras, thermographs, radiographs, ultra sonograms, ECG and EEG records etc.

Image theories

Aesthetics theories related to aesthetic proportion, study of beauty, harmony, and colour are presented in the book *Graphic design*. Language theories related to diagrammatic literacy, digital visual literacy, graphicacy, and graphical literacy are presented in the book *Text design*. Facilitating theories related to attention, perception, learning, and memory are presented in the book *Cognition*. However, all these areas of theory are also concerned with images.

From an image design perspective these areas are discussed in this book: (a) Visual language, (b) visual content, (c) execution of visuals, and (d) image formats.

Here are some facts, hypotheses, and postulates that are based on *image design*. (Some of these are also noted in other books.)

1. Visual languages have "analogue coding" employing combinations of basic graphic elements (dots, lines, areas, and volumes) for depicting reality. A given set of basic elements can be combined to form completely different images.
2. Visual languages attempt equivalence with reality. Visuals are iconic and normally resemble the thing they represent.
3. In visual languages meaning is apparent on a basic level, but the visual language must be learned for true comprehension.
4. Variables in visual language are related to content, context, execution, and format. Content is more important than execution, context, and format.

5. A “good” visual displays good legibility and good reading value. It conveys information without ambiguity, is attractive, and often aesthetically pleasing.
6. A “poor” visual displays poor legibility and poor reading value. It conveys information poorly, is seldom aesthetically pleasing, and often ambiguous.
7. Visuals may have many functions in communication. An intended subject may be expressed through many different pictures.
8. Visual communication, visual language, visual learning, visual perception, and visual thinking are inextricably linked to visual literacy.
9. In visual literacy creation and interpretation can be said to parallel writing and reading in print literacy.
10. Visuals, graphic form and text should always work together to fulfil information design objectives.
11. Visual content can only be measured by subjective means.
12. Visual messages are superior to verbal messages when content is emotional, holistic, immediate, spatial, or visual.

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