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Information Design 5

Cognition

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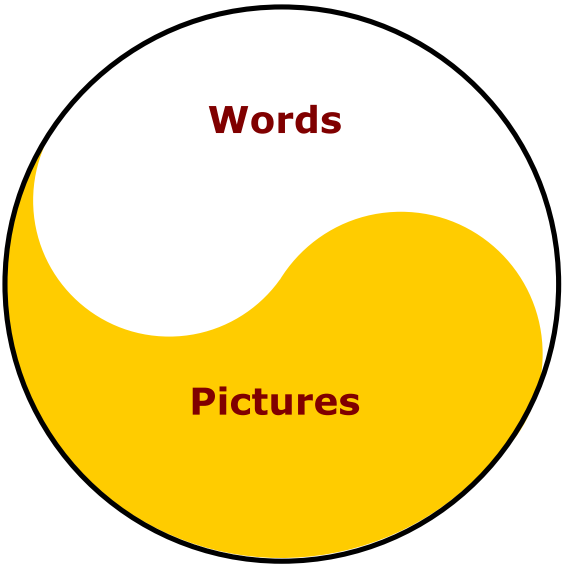

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Information Design 5–Cognition

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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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

Learning

We can assume that there is more than one learning process involved while we are learning. There are probably no distinct borders between learning processes. They probably interact, and work in parallel. Learning is parallel and spontaneous. We select and perceive *information* that we process into *knowledge*. The many available learning theories only offer explanations of certain learning situations. "Combined learning" is a holistic view of learning. We are using different processes for learning in different situations. Different situations require activation of different learning processes, or maybe "use of different learning tools." Obviously learning to walk is very different from learning to speak a foreign language.

The sensory organs and the brain work even when we are sleeping. In a normal life situation it is not possible to avoid learning. Most people are curious by nature. However, we are not always aware that we are learning something. Many people have experienced that they have good skills and knowledge in various areas. They may not be able to explain when and why they actually learned these skills.

When children are playing, it is easy to note their spontaneous learning. Children are active explorers of their environment. They may learn all the time. In fact, we may all learn as long as we live. In my view it is not possible to stop the sensory organs, nor the brain. We can assume that there is more than one cognitive process involved while we are learning. These processes may interact, and they may work in parallel, and they are influenced by our earlier experiences and memories. We also learn without being aware that we do so (Sun, 2008).

Learning theories

Every day, spontaneous learning is a natural part of our lives. Mellander (1993) explained spontaneous learning in the following steps: 1) attention, 2) information, 3) processing, 4) conclusions, and 5) application. Attention makes us receptive to information, which we process together with prior knowledge, until we arrive at conclusions and understanding, which we then apply and test for confirmation. This series of mental processes is also what film directors, authors, and politicians base their presentations on, in order to capture and hold our attention and to convey their messages to us.

A learning theory or a model for learning may be seen as a codified set of hypothesis about how individuals learn. Some researchers are trying to develop a single comprehensive learning theory encompassing all the different kinds of learning. As far as I know no such attempt has yet been successful. Uljens (1992) noted that there is no theory of learning that is widely accepted. Thus we have to deal with a large number of theories and models of learning, and learning processes, each useful in its own context. Theorists do not all agree about what learning is and how it comes about. Over the years that scholars have been interested in the process of learning, many elaborated theories of learning have been developed and tested. Kearsley (1999) described fifty different learning theories with references to those who have developed them.

- ACT* (J. Anderson)
- Adult Learning Theory (P. Cross)
- Algo-Heuristic Theory (L. Landa)
- Andragogy (M. Knowles)
- Anchored Instruction (J. Bransford and the CTGV)

- Aptitude-Treatment Interaction (L. Cronbach & R. Snow)
- Cognitive Dissonance Theory (L. Festinger)
- Cognitive Flexibility Theory (R. Spiro)
- Component Display Theory (M. D. Merrill)
- Conditions of Learning (R. Gagné)
- Connectionism (E. Thorndike)
- Constructivist Theory (J. Bruner)
- Contiguity Theory (E. Guthrie)
- Conversation Theory (G. Pask)
- Criterion Referenced Instruction (R. Mager)
- Double Loop Learning (C. Argyris)
- Drive Reduction Theory (C. Hull)
- Dual Coding Theory (A. Paivio)
- Elaboration Theory (C. Reigeluth)
- Experiential Learning (C. Rogers)
- Functional Context Theory (T. Sticht)
- Genetic Epistemology (J. Piaget)
- Gestalt Theory (M. Wertheimer)
- GOMS (Card, Moran & Newell)
- GPS (A. Newell & H. Simon)
- Information Pickup Theory (J. J. Gibson)
- Information Processing Theory (G. A. Miller)
- Lateral Thinking (E. DeBono)
- Levels of Processing (Craik & Lockhart)
- Mathematical Learning Theory (R. C. Atkinson)
- Mathematical Problem Solving (A. Schoenfeld)
- Minimalism (J. M. Carroll)
- Modes of Learning (D. Rumelhart & D. Norman)
- Multiple Intelligences (H. Gardner)
- Operant Conditioning (B. F. Skinner)
- Originality (I. Maltzman)

- Phenomenonography (F. Marton & N. Entwistle)
- Repair Theory (K. Van Lehn)
- Script Theory (R. Schank)
- Sign Theory (E. Tolman)
- Situated Learning (J. Lave)
- Soar (A. Newell et al.)
- Social Development (L. Vygotsky)
- Social Learning Theory (A. Bandura)
- Stimulus Sampling Theory (W. Estes)
- Structural Learning Theory (J. Scandura)
- Structure of Intellect (J. Guilford)
- Subsumption Theory (D. Ausubel)
- Symbol Systems (G. Salomon)
- Triarchic Theory (R. Sternberg)

The above learning theories are all from the 20th century. These theories provide very broad views of learning.

Learning options

Most people have a common understanding of "learning." Everyone agrees that we have to learn how to ride a bicycle and learn how to read. Bettinghaus and Cody (1987) extended this common-sense definition to a general definition of learning as the process by which some aspect of human behaviour is acquired or changed through an individual's encounter with events in the environment. Within learning, we include all our acquired ways of behaviour. We learn what to fear, what to love, how to be polite, how to be intimate, how to speak a foreign language, and so on. Phillips and Soltis (1991) noted that psychologists, anthropologists, linguists, neurophysiologists, philosophers, and others are still trying to understand how the mind works and how people learn. Brown et al. (1969) gave several examples of individualized learning options (p. 12) such as: produce learning materials, read textbooks, study charts, study pictures, and study reference books. They noted several experiences leading to learning (p. 31) such as: drawing, experimenting, observing, photographing, and thinking.

General prerequisites for learning

There are some general prerequisites for learning. For learning to occur we must be mentally prepared to learn. We must be interested and curious. We must be willing to learn! We learn better when we understand the reasons for learning, when we are motivated to learn, and when we work to achieve an important goal. If a person studies a subject, like history, so that it has meaning and is useful, he or she may like the subject. But if history represents a collection of unrelated facts that he or she is forced to memorise ("before the lesson on next Monday"), the reader is apt to dislike the subject and even consider it worthless. An individual who is motivated is someone that is ready to invest the necessary effort to change his or her cognitive structure.

Motivation

According to Brien and Eastmond (1994), the instructional designer and the trainer have an ingrained tendency to consider only the intellectual side of the learner. Designers and trainers frequently neglect the fact that the individual learner has needs, desires, emotions, attitudes, and values, and that motivation plays a key role in the processing of information presented. They noted (p. 15):

> The consequences of this omission are unfortunate, frequently resulting in instructional activities offering little stimulation, and over time creating an aversion to learning. It is a positive attitude toward learning that must be developed throughout instruction. Even though this is an unusual position for most cognitive scientists to take, this chapter treats the complementary roles of feelings and cognition as a necessary beginning for learning.

Brien and Eastmond (1994) postulated that motivation to learn is a function of at least three important factors: 1) The intensity of the needs felt by the individual, 2) The size of the learning task, and 3) The attitude held towards this task.

Linderholm (1997) concluded that many researchers agree that attitudes are learned, and that they influence our behaviour. However, researchers do not agree on a definition of the concept. There are more than 500 definitions of "attitude" in the literature (O'Keefe, 1990). McGuire (1985) provided a common definition (p. 239): "... responses that locate objects of thought on dimensions of judgement "...

Brien and Eastmond (1994) formulated a set of recommendations to assist the instructional designer, the teacher, and the trainer to enhance the learner's motivation to learn. They recommended:

- Help the learner to establish links between the competence to be acquired and the satisfaction of need.
- Use methods of teaching that will permit the satisfaction of individual needs.
- Vary the stimuli and the methods of instruction.
- Present challenging learning activities.
- Attend to prerequisite skills.

- Design activities that elicit pleasant emotions.

Livingstone and Lunt (1994) noted that most people more easily perceive information regarding issues that concern them, or for which they anticipate future practical use.

Influences

Learning is influenced by social factors, cultural factors, technical factors, individual prerequisites, biological factors, and psychological factors. We can distinguish between informal and non-systematic learning by socialisation, and formal learning and systematic learning, in accordance with formal curricula in schooling. Most of our learning is the result of spontaneous, informal, unconscious learning day after day, week after week, and month after month. It is important to note that only a small part of our knowledge is a direct result of formal education and formal study. Martin and Briggs (1986) ranked several influences on learning. In elementary and secondary schools they mentioned:

- Attitudes and values.
- Home environment.
- Instructional media.
- Intelligence.
- Learner strategies.
- Motivation.
- Peer influence.
- Public policy.
- Self-esteem and attribution.
- Teacher-pupil relationships.
- Teaching methods and quality of instruction.
- Time on task.

For adult learning Martin and Briggs (1986) added the following influences: emotions, expectations of the future, feelings, life style, organizational policies, and personal goals.

Learning improves when we have a positive attitude both to the subject matter and to our own ability to learn. Learning improves when information is relevant and meaningful to the subject matter. In my view information must correspond to an interest or a need in the learner. Information must have good legibility, good readability, and be well worth reading. We must be able to *understand* the message.

Presentation of information

Learning is affected by the presentation of information. Learning improves when the same information content is presented in different representations: words, pictures, and sound (Paivio, 1983, 1986; Pressley & Miller, 1987). The representations shall have a redundant or a relevant relationship. Learning improves when the same information is presented in different media. Learning improves as the quality and depth of the cognitive engagement and processing increases, and declines as the quality of engagement decreases. Regular exercise is reported to improve learning (Dryden & Vos, 1994).

Brien and Eastmond (1994) developed a model explaining learning as a means of attaining one's expectations. To satisfy a particular goal, the individual must pass through intermediate stages or sub-goals. To complete these sub-goals, the person must carry out tasks. If the competence to complete these tasks is lacking, the person must learn and undertake the assembly and the refinement of competencies that permit accomplishment of tasks.

Thus, Brien and Eastmond consider competencies as being themselves sub-goals, the attainment of which facilitates the accomplishment of tasks that permit the realization of goals, and thus the satisfaction of the person's individual needs. They postulated that the affective processes coming into play during the accomplishment of a learning task are the same as those present during the accomplishment of any task in general. Bettinghaus and Cody (1987) provided principles that help explain why people respond differently to the same message:

- Individuals differ in their ability to respond to a message.
- Individuals differ in their readiness to respond to a message.
- Individuals differ in their motivation to respond to a message.
- Reinforcement is helpful in establishing response.
- In learning, active participation is better than passive participation.
- Meaningful responses are easier to learn than meaningless responses.

According to Barry (1998) the British researcher in preconscious processes Norman Dixon has researched and written extensively on perceptual processes functioning below the level of our conscious awareness. As early as 1971, before the use of such technological medical tools as magnetic resonance imaging confirmed it. Dixon argued for the presence of a dual perception system. One was associated with involuntary process and emotional thinking, and an evolutionary later one that involved logical, rational, and verbal cognitive operations.

Also in accordance with Blum (1986), the human mind functions on subconscious and on conscious levels of awareness and perception. The subconscious mind is readily accessible and receptive to various forms of suggestions and stimuli that can influence and alter the conscious level thought and behavioural patterns. Our eyes are extremely sensitive to visible light wavelengths, visible light that is often not even seen, visually recording all that we see and do not see with exact precision. Blum maintains that there is an "unseen visual environment" that can and does provide suggestive stimuli to the subliminal level of consciousness.

It is not always understood that learners have to work to learn. Winne (1995) noted that students often overestimate their possibilities to learn and underestimate the effort that is needed. It is obvious that learning is affected by many different factors, also by the presentation of the information.

Performance and learning objectives

Working closely with the two information design models reveals that they may be used to explain and describe also other interdisciplinary areas of knowledge, such as persuasion design and instruction design.

Information design students (161) were asked to evaluate any perceived differences in the influence of individual groups of disciplines on persuasion design and instruction design, in comparison with information design. For each group of disciplines the students had to judge if the influence was less, equal, or more important to persuasion design than to information design; and less, equal, or more important to instruction design than to information design. Most students felt that language disciplines are of equal importance for persuasion design and information design, but more important for instruction design.

Art and aesthetics disciplines, however, were felt to be more important to persuasion design, but less important to instruction design. Information disciplines were evaluated as equal important to persuasion design, and more important to instruction design. Communication disciplines were evaluated as more important to persuasion design and instruction design. Behavioural and cognitive disciplines were evaluated as less important to persuasion design, but as equal or more important to instruction design. It is obvious that student subjects evaluate a difference in importance of the "base disciplines." This may be explained with clear differences in intentions and objectives.

Learning outcomes

There are a number of taxonomies for classification of learning outcomes. Bloom et al. (1956) proposed three domains of learning. These are: 1) the cognitive domain, 2) the psychomotor domain, and 3) the affective domain. This taxonomy has had an enormous influence on education. It has prompted educators to clarify, classify, and develop learning objectives. Much later Krathwohl (2002) made an extensive revision of the cognitive domain. The revision includes six cognitive process dimensions: 1) remember, 2) understand, 3) apply, 4) analyse, 5) evaluate, and 6) create. Four knowledge dimensions can be applied to each cognitive process: 1) facts, 2) concepts, 3) procedures, and 4) meta-cognitions.

Gagné and Briggs (1974) identified five types of learning that they called "Human Capabilities." These types are: 1) intellectual skills, 2) cognitive strategies, 3) information skills, 4) motor skills, and 5) attitudes. Later Gagné (1977) discussed the following types of learning:

- Signal learning (classical conditioning).
- Stimulus-response learning (operant conditioning).

- Chaining (connecting of motor stimulus-response connections).
- Verbal associations (learning of chains of words).
- Discrimination learning (different responses to similar stimuli).
- Concept learning (learning to make a common response to a category of stimuli).
- Rule learning (using general rules for different examples).
- Problem solving (application of old rules to a new situation).

Heinich et al. (1982) have identified criteria for domain classification as well as four "levels" of learning objectives in each of the three domains. These levels of learning are noted in later chapters. In accordance with Mager (1991), an objective is a performance that you want learners to be able to exhibit before you consider them competent. An objective describes an intended result of instruction or training, rather than the process of instruction itself. An objective always states a performance, describing what the learner will be doing when demonstrating mastery of the objective. While a goal is a general statement for a topic, learning objectives are specific outcomes for learning.

According to Gagné (1985), objectives help to activate a mental set that focuses student attention and directs selective perception of specific lesson content. Kemp and Cochern (1994) noted that it is important to give students a list of required learning objectives. Then the students will know what is specifically required of them and by what standards their learning will be evaluated. According to Clark and Lyons (2004, p. 321) the five most common lesson content types are 1) procedures, 2) concepts, 3) facts, 4) processes, and 5) principles. Each content type needs specific types of instructional graphics. *Procedures* are tasks that involve the same steps each time they are performed. *Concepts* are supporting knowledge that involves a category of events, ideas or objects usually designated by a single word. *Facts* are supporting knowledge that designates specific and unique content about events, objects or people. *Processes* are supporting knowledge that describes state changes about how systems work. *Principles* are comprehensible laws that include predictive relationships.

Learning objectives are most often derived from subject content and direct the selection of instructional activities and resources, and specify the way to test student learning. According to Kemp and Cochern (1994) learning objectives consist of up to four parts: 1) Verb, 2) Content component, 3) Performance standard, and 4) Condition. The first two parts are essential, and the others are optional.

Reviews of research have supported providing objectives to learners. However, inconsistencies in the results of this research have suggested that learning objectives may not be effective in every learning setting (Duchastel & Merrill, 1973; Hamilton, 1985; Hannafin & Hughes, 1986). Learning objectives may increase the attainment of factual information, but do little to help students process higher level skills (Clark, 1984; Hannafin, 1985; Ho et al., 1986; Mayer, 1984). Duchastel and Brown (1974) have reported that learning objectives enhance learning of relevant content, but may inhibit learning of incidental material.

According to Heinich et al. (1992) the psychomotor domain may be seen as a progression in the design of the coordination that is required. The levels are: 1) *Imitation*: repeating an action that is shown. 2) *Manipulation*: performing independently. 3)

Precision: performing with accuracy. 4) *Articulation*: performing unconsciously, efficiently, and harmoniously.

The cognitive domain is based on a progression from simple to complex mental performance. Here Heinich et al. put: 1) *Knowledge*: recalling specifics, remembering, defining, recognising, repeating. 2) *Comprehension*: translating, interpreting, paraphrasing, summarising, extrapolating. 3) *Application*: using ideas and information. 4) *Creation*: combining components to form results.

The affective domain is organised in accordance with the degree of internalisation, the degree to which the attitude or value has become a part of the individual. Heinich et al. noted: 1) *Receiving*: being aware of and willing to pay attention to stimulus (listen or look). 2) *Responding*: actively participating, reacting. 3) *Valuing*: voluntarily displaying of an attitude, showing an interest (after valuing, Krathwohl et al., 1964, have "conceptualizing organization"). 4) *Characterization*: demonstrating an internally consistent value system.

Different objectives

Several researchers have pointed out that it is important to define clear objectives in message design (Fleming & Levie, 1993; Heinich et al., 1982; Marsh, 1983; Mullet & Sano, 1995, Pettersson, 1999; Wileman, 1993). A performance, and a change in behaviour, must be observable. Thus subjective objectives defined by verbs like appreciate, assess, describe, discuss, evaluate, know, outline, and understand should be avoided. A statement of design objectives should include the conditions under which the required performance is to be observed and measured, when such conditions are relevant. Time and accuracy are often meaningful dimensions in assessment of objectives. When performance is qualitative rather than quantitative, the performance may be assessed by a group of experts.

Various areas of design have different objectives and the materials and products reach out to different groups of receivers. Based on the intended purposes, the different areas related to design of information sets and information materials may be grouped into five main categories:

Graphic design objectives

In graphic design the main objective is to provide functional, aesthetic, and organised structure to all kinds of information sets. The information interpreter might be seen as a "reader." They may develop new views, relaxation, emotions, awareness, attention, and understanding. It may be an advantage to use verbs like find, identify, read, and recognise. These verbs all denote observable behaviour. A few examples of performance objectives in graphic design may be:

- For a *table*: 100% of the users should be able to find the time for departure of the train to x.
- For a *package*: 100% of the buyers should be able to read the text on the package without any difficulty.
- For a *logotype*: 60% of the readers should be able to identify a new logotype within six weeks.

Of course the actual numbers, with respect to percent and allowed time, have to be decided in each specific case.

Mass design objectives

Mass design includes aspects from communication studies, mass-communication, media studies, and journalism. Here the main intentions are to provide news, views, and entertainment. The information interpreters might be seen as "relaxers." They may develop views, relaxation, emotions, and awareness. In mass design it may be an advantage to use verbs like feel, laugh, look, read, and relax. These verbs all denote observable behaviour. A few examples of performance objectives in graphic design may be:

- For a *magazine*: 100% of the readers should be able to read the text in the magazine without any difficulty.
- For *news* on television: 70% of the subscribers should look at the program at least once every day.
- For *entertainment* on television: 80% of the viewers should have fun and laugh at the jokes.

The actual numbers, with respect to percent and allowed time, have to be decided in each specific case.

Persuasion design objectives

In persuasion design the main objective is to persuade the interpreter of the message to buy a product or a service, or to change his or her behaviour. The information interpreters might be seen as “possible buyers,” “prospects.” They may develop new prejudices, apprehensions, willingness to buy, beliefs, reinforced attitudes, emotions, opinions, and views. It may be an advantage to use verbs like appreciate, believe, buy, change (behaviour), desire, dread, fear, feel (relaxed), hate, and have (fun) in the writing of persuasion design objectives. These verbs all denote observable behaviour. A few examples of performance objectives in persuasion design may be:

- In *propaganda*: 90% of the population should hate a specific behaviour when they have heard the arguments.
- In *advertising*: 50% of the readers should buy the new consumer product within two weeks.

- In *marketing*: The market share for a particular product must increase from ten to 25% within one year.

The actual numbers, with respect to percent and allowed time, have to be decided in each specific case.

Information design objectives

In information design the main objective is to provide information materials needed by the interpreter in order to perform specific tasks. The information interpreters might be seen as "doers." They may develop new skills, understanding, and experience. It may be an advantage to use verbs like apply, arrange, assemble, build, change, code, complete, compose, conduct, construct, cut, demonstrate, develop, draw, explain, find, generate, get, identify, illustrate, install, label, locate, make, modify, name, operate, pack, paste, predict, prepare, produce, put, read, recognise, reconstruct, remove, revise, sort, specify, start, type, verify, and write in the writing of information design objectives. These verbs all denote observable behaviour. A few examples of performance objectives may be:

- For an *exhibition*: 90% of adult visitors should be able to read the texts on labels used in the exhibition without any difficulty.
- For an *instruction*: 90% of the customers should be able to follow the instructions, put the different parts together, and build a complete set of furniture within 15 minutes.
- For a *traffic information system*: 100% of motorists should recognise the signs while they are passing during night.

The actual numbers, with respect to percent and allowed time, have to be decided in each specific case.

Instruction design objectives

In instruction design the main objective is to provide courses and learning materials needed by the interpreter in order to modify behaviour with respect to learning. The information interpreters might be seen as “learners.” They may develop new understanding, experience, comprehension, knowledge, insight, and finally wisdom. It may be an advantage to use verbs like apply, arrange, complete, compose, conduct, construct, define, demonstrate, explain, find, identify, illustrate, label, modify, name, predict, prepare, recognise, reconstruct, revise, specify, verify, and write in the writing of instruction design objectives. These verbs all denote observable behaviour. A few examples of performance objectives in instruction design may be:

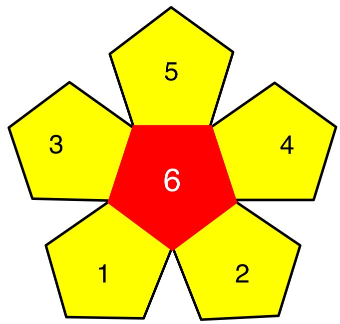
- For an educational *video program*: 90% of the students should be able to illustrate the main topic in the program.
- For an *experiment*: 90% of the students should be able to explain the various steps in the experiment.
- For a *textbook*: 90% of the users should be able to explain four ideas presented in the text.
- For an *excursion*: 100% of the students should be able to identify and name five of the most common flowers in the area during the excursion.
- For an *exercise*: 100% of the students should be able to complete the exercise within 15 minutes.

Also here the actual numbers, with respect to percent and allowed time, have to be decided in each specific case.

Combined learning

Personally, I prefer to view learning and learning theories from a process perspective rather than from a traditional outcome perspective. Learning models may be grouped in six main categories from a process-perspective. These categories are: 1) Perceptual motor-skill learning. 2) Associative learning. 3) Learning from analysis and problem solving. 4) Social learning. 5) Learning from representations. 6) Combined learning.

From a process perspective we can see six groups of learning theories: 1) Perceptual motor-skill learning, 2) Associative learning, 3) Learning from analysis and problem solving, 4) Social learning, 5) Learning from representations, and 6) Combined learning.



Attention, perception, processing, and application are the basis for *Combined learning* and the mental spiral model of learning that I have called the *Learning Helix* (Pettersson, 1995a). This model is discussed in detail in later chapters.

About the same time also Nonaka and Takeuchi (1995) used the helix metaphor and proposed a *knowledge spiral* that aims to explain how individuals and groups convert knowledge from a tacit to an explicit form and vice-versa, and then share both tacit and explicit knowledge.

This model was subsequently further developed by Nonaka, Toyama and Nagata (2000). Here the helix metaphor reproduces an upward evolutionary path, with an unlimited continuity perspective, in which the reaction loops do not tend to close in the form of the classic feed-back but act as virtuous circles (Miron, 2008).

Attention

Among the thousands of stimuli in the external context we only see, hear, smell, feel, taste, or “pay attention to” one stimulus at a time. Attention is sudden, direct, and distinct. The sequential flow of attention to the parts of a message is determined by the sequence in which information is presented to us. There are always far more stimuli than we can ever notice at any given situation. To us most stimuli remain unknown, unseen and unheard of. Attention, or mental preparedness and receptiveness, can be considered as the activation of groups of brain cells. Smell, taste and feeling are very important senses in natural life, but they are not as yet important factors when we want to use traditional media. We can pay attention to the *content* of a message, to the *execution* of that message, to the *context* in which the message is presented, and to the actual *format* or *medium* that carries the message. Attention is the first step in the *Learning Helix*.

Our senses

Sense organs are the only way that we can record and observe the world outside our own bodies. If we are aware of the limitations of our senses we can make better decisions about the accuracy of what is happening. Natural selection favours qualities that are needed for survival. Thus our senses operates at the level of overt behaviour that enables us to avoid predators, find food, find mates, and move around from one place to another in our environments.

Smell, taste, and the sense of feeling are important senses in natural life and often grab and direct our attention. However, they are not yet especially important factors to be considered when we want to use information conveyed in messages that are distributed with traditional media based on sound and vision.

A great deal of the experimental work during the early years of the twentieth century was devoted to determining the impact of the intensity of a stimulus, such as the loudness of sounds, the brightness of lights, and the strength of pressure, on attentional processes. The duration of a stimulus and the concomitant phenomena of adaptation and fatigue were also studied (Urbina, 1994).

We are capable of successfully smelling, tasting, feeling, hearing and seeing things at the same time. We are also capable of simultaneously hearing different stimuli in either ear. However, we are probably incapable of simultaneously perceiving different stimuli aimed at the right and the left eye, respectively. The same kind of stimulus may easily be perceived in different ways at different times.

Highly developed perceptual abilities are needed to detect the bounds of a single image within a complex structure. Young children may choose to pay attention either to the whole picture or to only specific parts of it. For children until about nine years of age it might be difficult to switch attention between a specific part and the whole.

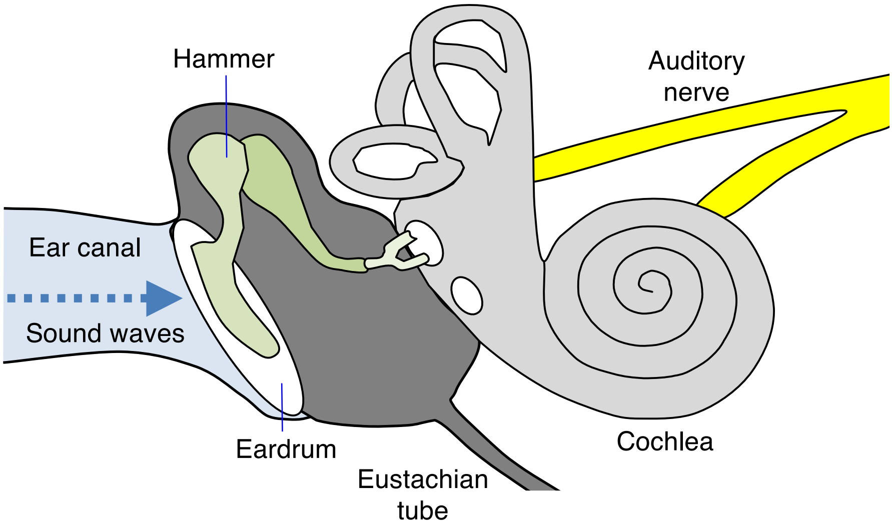
The process of attention determines which events we become conscious of. Attention may be controlled 1) automatically, 2) by instructions, and 3) by the specific demands of the particular task at hand. A visual material must constantly redraw the attention to hold the interest of the viewer. Our perception varies as a result of a number of factors. Visual information is processed quickly. Seeing is direct and effortless. We do not become conscious of all the stimuli detected by our sensory organs.

The selective process that controls our awareness of events in the environment is called attention. The information designer may use various design principles and guidelines in order to facilitate the reader's attention processes, and subsequent processes for understanding and learning. We direct our attention to what we happen to be interested in; to special sounds; to things that move; are large, bold, and clear; are new; have bright colour, an unusual shape, or a good contrast; and that deviate from the surroundings or from familiar patterns. We direct our attention to contents that arouse feelings and needs.

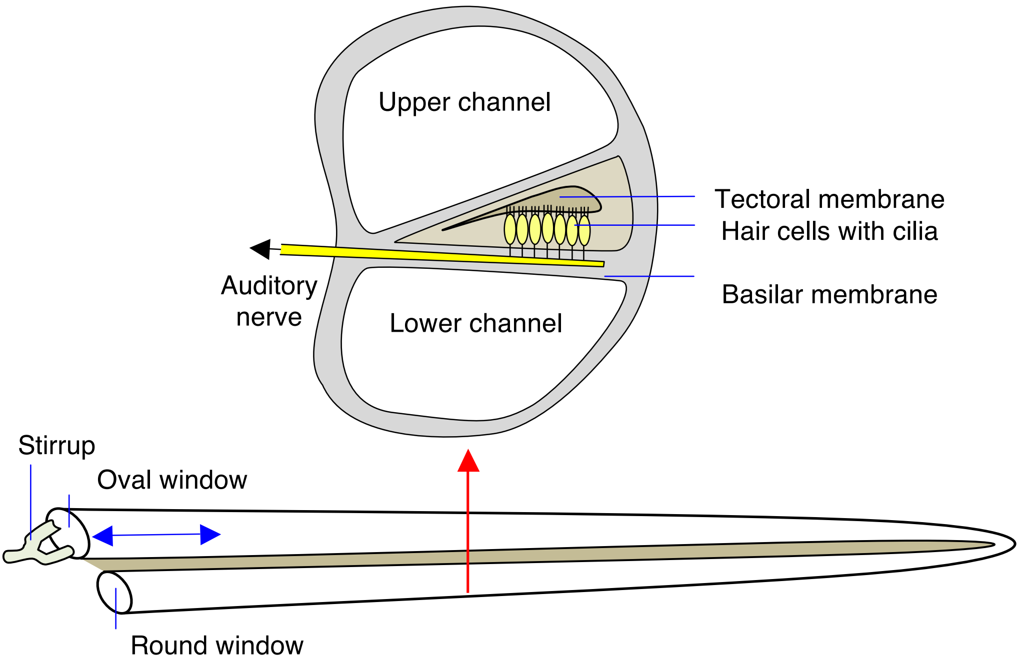
Hearing

Sound is a subjective sensation of hearing. The sensory cells in the inner ear's hearing apparatus are stimulated and signals sent to the brain where they are perceived as sound. In objective terms, sound consists of longitudinal wave motions capable of acting on our hearing apparatus and thereby eliciting sound sensations. Man is normally capable of perceiving sound waves at frequencies from 16 to 20,000 Hz. Sound waves lower than 16 Hz are referred to as infrasound, and frequencies higher than 20,000 Hz are referred to as ultrasound.

Sound pressure waves make the eardrum vibrate. The vibration is passed on to the three small bones in the middle ear. The movements of the third bone, the stirrup, against the membrane in the oval window create changes in pressure in a fluid within the cochlea, the inner ear. When the oval window is moving in the round window bulges outward. The fluid causes a basilar membrane to flex back and forth. The auditory cells are located on this membrane. These cells cause the neurones of the auditory nerve to send signals to the brain for processing. Different frequency sounds are perceived when different parts of the basilar membrane vibrate in response to these frequencies.



Sound waves entering the ear canal (light blue) are transmitted from the eardrum via the three small bones (hammer, anvil, and stirrup) in the middle ear (dark grey) into the inner ear (light grey). The three semicircular canals at the top belong to our sense of balance.



Here the cochlea in the inner ear is stretched out (bottom). When the stirrup pushes against the membrane in the oval window the fluid in the cochlea is moving and the round window bulges outward. Various sound frequencies cause flexing of different portions of a basilar membrane with receptive hair cells (cross section). The hair cells send signals to the brain via the auditory nerve.

Sound intensity, i.e., the average rate of sound energy transmitted per unit of time and unit area that passes a plane perpendicular to the transmission direction, is an objective measure of sound intensity. It is usually measured in w/m2 (watts per square meter). However, a psychologically based concept is necessary in order to designate the strength of sound waves striking our ears. The hearing range is the interval between the lowest sound intensity we are capable of perceiving, i.e., the auditory threshold, and the highest level we are able to tolerate, i.e., the pain threshold.

Vision

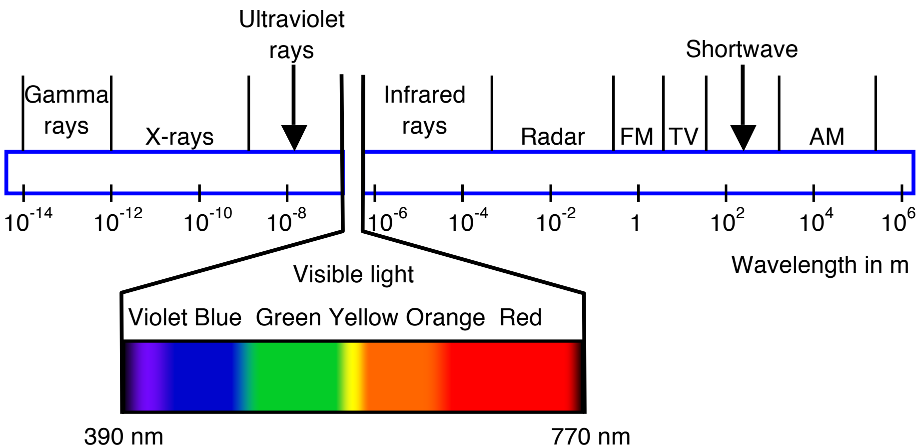
Natural selection favours qualities that are needed for survival. Our visual system is remarkable. We are capable of perceiving objects in bright light from the sun, and in pale light from the moon. We can also follow rapidly moving objects. Thus vision operates at the level of overt behaviour that enables organisms to avoid predators, find food, find mates, and move around from one place to another in their environments. In subjective terms vision is a complex process that elicits a sense of vision, i.e., awareness of the stimulation of the eye's vision perception cells. In objective terms, light consists of electromagnetic waves (light "rays") capable of acting on our eyes and creating sensations of light and images.

The *opponent process theory* and the *tri-chromatic theory* are two complementary theories of colour vision. The opponent process theory, or the *Hering theory*, states that the visual system interprets colour in an antagonistic way: red vs. green, blue vs. yellow, black vs. white. The tri-chromatic theory, or *Young-Helmholtz theory*, states that the retina's three types of cones are preferentially sensitive to blue, green, and red. These theories describe different stages in visual physiology.

Visible light

Human vision is sensitive within a wide wavelength range, from violet to dark red. Visible light ranges from 3 900 angstroms to 7 700 angstroms (0,00039–0.00077 millimetre). The wavelengths for violet is 3 800–4 200, for blue 4 200–4 900, for green 4 900–5 750, for yellow 5 750–5 850, for orange 5,850–6 500, and for red 6 500–7 500. Green–orange is in the region of the eye's greatest sensitivity. Sensitivity decreases markedly toward the red and the violet ends of the spectrum.

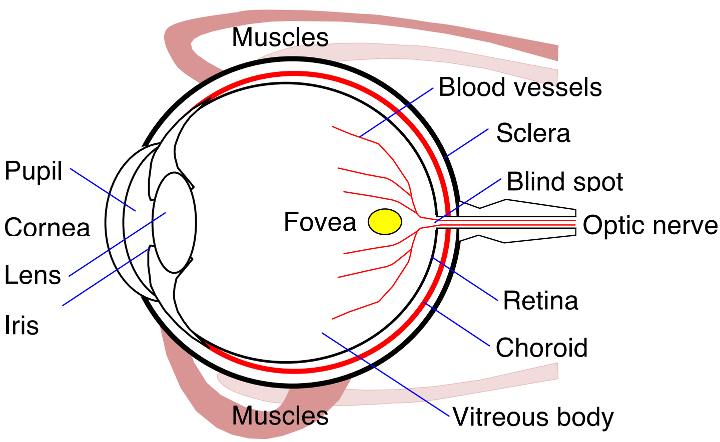
Like sound waves, light waves are propagated in straight lines from their source. They can also be reflected, refracted, bent, and absorbed. The velocity of light in air is nearly 300 000 km/s. When light rays (usually parallel) from an object enter the eye, they are refracted in the cornea and lens and pass through the vitreous humour until they strike the retina. When the ambient light level is high, the light rays strike the macula lutea, the fovea, a small area of the retina that is rich in cones. Cones are the receptors that record colours.



This is an illustration of the electromagnetic energy system. The portion of the spectrum perceived as visible light is enlarged in the illustration above.

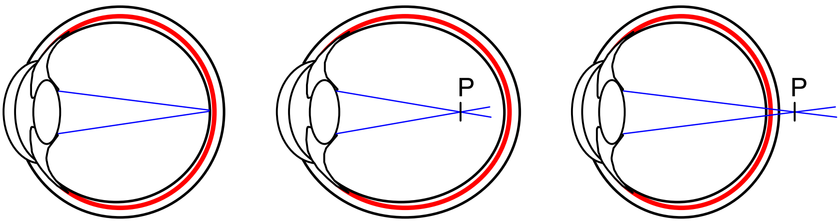
The classical view is that each sensory organ picks up individual sensory impressions that are interpreted more or less individually. The retina's receptors are excited by light and respond by chemically converting a pigment, rhodopsin (visual purple). This conversion triggers impulses that are transmitted along the optic nerve and the thalamus to the brain's primary visual cortex. This takes only a few milliseconds. In the visual cortex the impulses are translated into a sensation of vision.

The visual angle is a key concept in defining the properties of the eye. Visual angles are generally defined in degrees, minutes and seconds of arc. An object of one cm viewed at a distance of 57 cm has a visual angle of approximately one degree.



This is a cross section of the human eye.

Often the lens has a natural shape that is inappropriate for the length of the eye. Then either near or far stimuli cannot be adequately focused. When the axial length of the eye is too long for the lens, the light rays reflected by distant objects are always refracted such that the image of the stimulus is formed before the retinal plane. However, close objects are properly imaged on the retinal plane. This condition is called nearsightedness or myopia. In the opposite case, the axial length of the eye is too short for the lens. Now the light rays reflected by near objects are refracted such that the image of the stimulus is formed behind the retinal plane. However, distant objects are always properly imaged on the retinal plane. This condition is called farsightedness or hypermetropia.



The conditions of myopia (left) and hypermetropia (right), P=plane of focus.

Visual fields

The optic nerve has about one million optic nerve fibres leading from the ganglion cells. In the fovea there is an almost one-to-one connection between cones and fibres, whereas as many as 600 rods may be connected to one optic nerve fibre in the outer periphery of the retina. This helps to explain why visual acuity is best in the fovea. When light rays from an object are bent in the cornea and lens, an upside-down image of that object is formed on the retina.

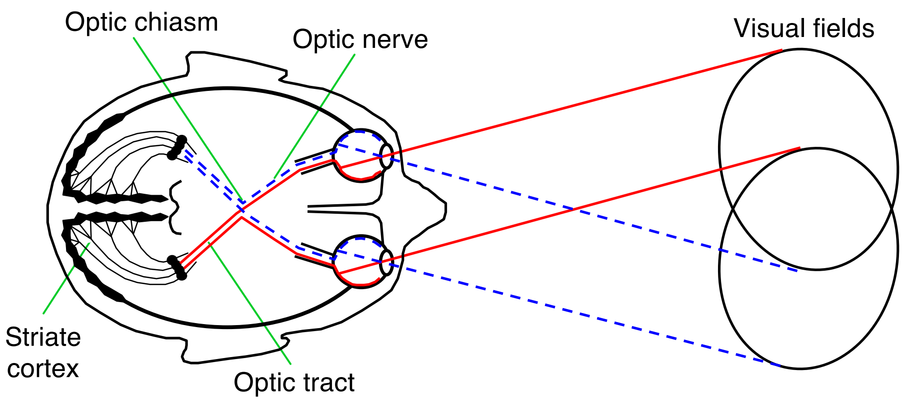
Very small children view the world as being upside-down. After a time, however, the brain somehow learns to process retinal images so that they are perceived to be right-side-up. According to Nakayama et al. (1995) vision is an extremely complex process. About half of the cerebral cortex may be engaged in processing of visual information. Different parts of the visual field have their exact counterparts in the visual cortex. Nakayama et al. (1995) wrote (p. 4):

> By painstakingly recording from one nerve cell at a time, neurophysiologists have pieced together an unusually detailed account of how neurons respond to visual input at various stages of the visual pathway—from the photoreceptors, to the visual cortex, and beyond. Not surprisingly, photoreceptors are sensitive to just a small localized part of the visual field, responding only when light is presented in this very small region.

The primary visual cortex is organized into some 2,500 rectangular areas, called "tiles." Each tile consists of a block of tissue, approximately 0.5 x 0.7 mm with some 150,000 neurons (Carlson, 1993). Each tile receives information only from a small part of the retina. In the tiles neural circuits analyze information about movement, depth, orientation and width of lines and edges, and also colour. Information from each tile is then sent to all sub-regions of the first level of the nearby visual association cortex.

The second level of the visual association cortex in the temporal lobe receives information about orientation and width of lines and edges as well as colours for perception of three-dimensional shapes and colours of objects. The second level of the visual association cortex in the parietal lobe receives information about depth and movement. Here this information is combined with information about movements of the eyes, the head and the body for spatial perception of location and movementes of objects.

Since we have two eyes, both pointing forward and with partially overlapping visual fields, we can assess the distance, both forward and laterally, between objects. It takes a certain amount of time for the eye to record light rays from an object, such as a painting. And it also takes time before we are capable of perceiving that object as an image. The eye has inertia. This inertia enables us to perceive motion. When we look at a person who is walking or running, the eye records a series of stills that ultimately blend into one another and form a moving image. This inertia also enables us to see motion in the stills that comprise a movie film or a TV image.



This is an illustration of the optic pathways, showing partial crossing of optic nerve fibres at chiasm. Information from each eye reaches both halves of the brain.

Nowadays, however, sensory organs are often described as sensory systems and the total energy flux striking them viewed as information about the surrounding world and about ourselves. The individual sensory organs receiving this information are not merely passive receptors but jointly constitute an active, exploratory system in which all the senses intimately interact, supplying us with an undergirded view of the world. So we are spared the task of having to consciously translate a myriad of individual sensory impressions into coherent perception.

According to Gibson (1966) the eye does not really operate like a camera. We are never conscious of the "stills" formed on the retina. We only perceive the external world they represent. The eye and head shift their attention constantly from one point to another in our surroundings or in a picture. Thus, our vision is an active, exploratory process. We usually concentrate our attention to interesting events within a narrow segment of our total field of vision. Bergström (1974) noted that visual information on our surroundings is conveyed to the eye, a very imperfect optical system.

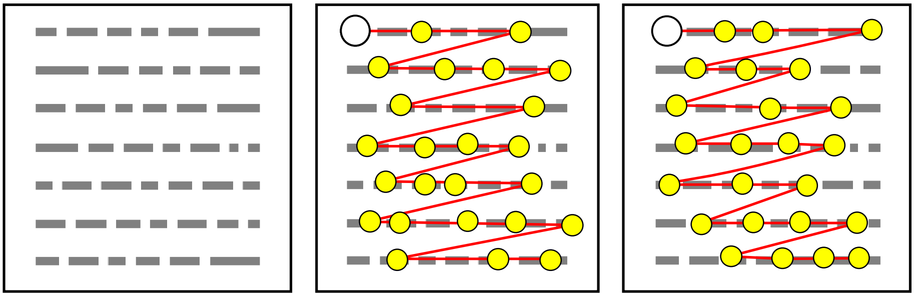
Eye movements

Our eyes never remain still. They tremble at a frequency of about 30-90 Hz. This serves to shift information of individual cells. The eye alters its fixation point constantly. It also makes constant small jumps. We constantly "scan" the things we look at. By using complex instrumentation that allows the researcher to record exactly where in a picture a person is looking at any given moment, it is possible to study the way in which the gaze wanders over a picture, pauses and fixes on certain points (Antes, 1974; Baron, 1980; Berlyn, 1966; Biederman, 1981; Buswell, 1925; Faw & Nunnaly, 1967, 1968; Fleming, 1969; Gould, 1967, 1973; Guba et al., 1964; Hochberg & Brooks, 1978; Leckhart, 1966; Loftus, 1972, 1976, 1979; Mackworth & Morandi, 1967; Nesbit, 1981; Noton & Stark, 1971a, 1971b; Pettersson, 1983a; Webb et al., 1963; Wolf, 1970; Yarbus, 1967; Zusne & Michels, 1964). The gaze never fixes on most parts of a picture. Only certain image elements capture our attention.

Yarbus (1967) found that fixation usually lasts for two to eight tenths of a second and that eye movements between eye fixations took from one to eight-hundredths of a second. So we normally view a picture by means of a large number of eye movements and eye fixations in rapid succession. The location of each fixation influences how a picture is interpreted and later remembered (Nelson & Loftus, 1980).

Faw and Nunnaly (1967, 1968) found that new pictures require more eye fixations than pictures with which subjects were already familiar. When the learner does not see, read, or hear what she or he is expected to, or can't find agreement between verbal and visual content, the message is likely to be misunderstood. We will pay attention to very large and to very small objects that differ in size, as well as any object with a special, interesting, or unusual shape or unusual colour in a picture, and in our surroundings.

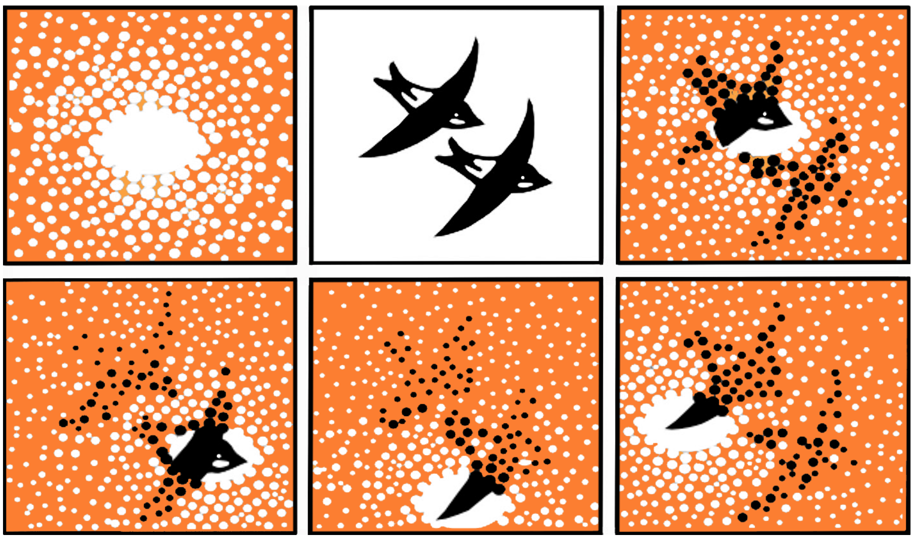
Human brains are designed to understand images (Medina, 2008). Looking at pictures is a "natural" way of free exploring. However, reading a text needs to be very structured with several eye fixations on each line. The time for each fixation varies among individuals and different texts (Ekwall, 1977), with the average time for good readers between 1/4 to 1/6 of a second. It also takes from 1/25 to 1/30 of a second for the eye to move from one fixation to the next and sweep from the end of one line to the beginning of the next. At normal reading distance the angle of convergence is about 20. Then the text within foveal vision is five to seven letter spaces (one cm). Normal reading speed is five to ten words per second or 300-600 words per minute. Lawson (1968) has established the physiological limit of reading as being a maximum of 720 words per minute. Ekwall (1977) calculated the maximum reading speed of the most efficient reader as being 864 words per minute under ideal conditions.



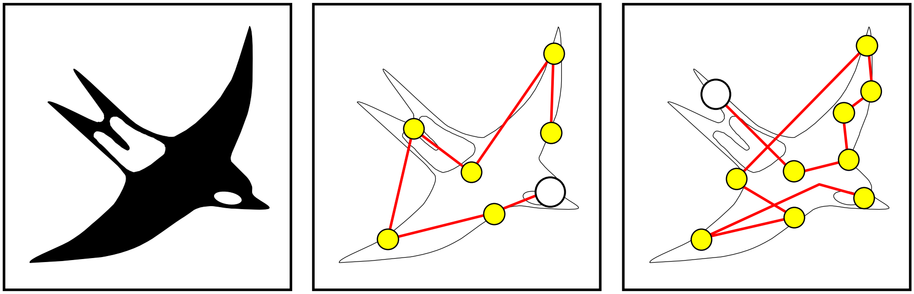
Here are examples of eye fixations when two persons read a small section of a text (left). The white circles are the places for the first fixations. We read a text in a structured way with fixations along the lines, not on every word, and not always on the actual words (yellow dots). Each person will read the text somewhat different. We don't see the movements (red lines).

Outside of the fovea the number of sensory cells decline. Here the retina is less sensitive. However, these sensory cells are important for our "peripheral vision," which is especially sensitive to movement and brightness, both highly relevant to the detection of any approaching danger. The right hemisphere of the brain is largely processing this fuzzy peripheral vision (Heilman, Chatterjec & Doty, 1995). Following this initial global surveying action, the brain identifies areas for more specific sharp focusing.

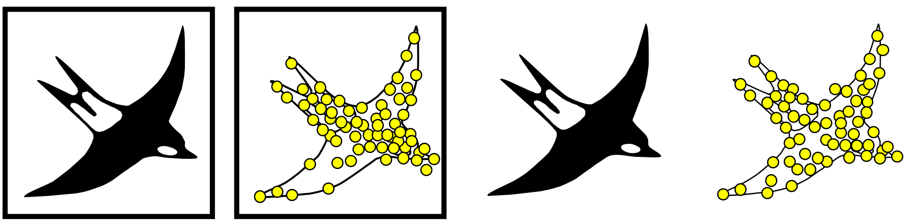
Yarbus (1967) found that instructions given prior to viewing determined what segments of the picture received the most attention. The pattern of eye movements and fixations is entirely different when our objective is to search for something in a picture. The things we wish to see in a picture have a major impact on the location of eye fixations. Where we look and why we look there determines what we see. Outside of the fovea the number of sensory cells decline. Here the retina is less sensitive. However, these sensory cells are important for our "peripheral vision," which is especially sensitive to movement and brightness, both highly relevant to the detection of any approaching danger.



These illustrations show a model of the "stills" that are formed on the retina during our eye fixations. There are plenty of sensory cells in fovea, the large white oval in the upper left picture. When we look at a picture like the one with two birds (upper middle) we only see some parts of it, and only some sensory cells are activated (upper right). Eye fixations are rapid, usually four to six per second. The three illustrations at the bottom demonstrate that only certain cells are activated at any time. We are never aware of the "stills" on the retina.



Here are examples of eye fixations. Each fixation takes about 1/5 of a second. In this case subjects got the instruction: "Tell me what you see!" It takes only a few seconds for adult subjects to recognize and "label" the content in a simple picture. Some parts of a picture are never "seen." In each case the white circle is the place for the first fixation. We don't see the movements (red lines).



This illustration shows fixations by a number of subjects on two pictures, "bird with and without frame." Some parts of a picture are never "seen." Subjects are aware of the frame (left) but there are no fixations on it.

Dake (1999) argued that visual literacy begins when the eyes scan the visual field and make highly selective choices of spatial information to construct a stable mental image of the world. One study (Zangemeister, Sherman & Stark, 1995) discovered that non-professional subjects used almost exclusively small, local scan-paths. Professional subjects, however, made many global scans and had a large ratio between local to global scan paths. Global to local scanning means that we notice the overall structure or figure first and then the details or informative areas (Antes and Penland, 1981; Biederman, 1981; Navon, 1977; Printzmetal & Banks, 1977). Thus we quickly find out which details of a picture are the most informative ones, and then we concentrate our attention to those parts. This global to local scanning would seem to indicate that to get maximum impact from a visual, the writer or the presenter should introduce the image content before presenting the visual.

When reading an illustrated text many readers use the "global to local scanning" method. Readers 1) glance briefly at the picture, 2) read the text, and then 3) return to the picture (Rayner et al. 2001; Underwood, 2005; Eitel et al. 2010). However, some studies have shown that readers start finish the text and then look at the picture (Schmidt-Weigand, 2009).

A number of scientists have found that pictures that are hard to interpret require more eye fixations than "easy" pictures (Berlyn, 1966; Faw & Nunnaly, 1967, 1968; Hochberg & Brooks, 1978; Leckhart, 1966; Mackworth & Morandi, 1967; Webb et al., 1963; Zusne and Michaels, 1964). Wolf (1970) determined that "difficult" pictures require more fixations up to a certain point. When a picture was extremely difficult, subjects tended to avoid looking at it or searched for a visual centre. However, neither Baron (1980) nor Nesbit (1981) found any correlation between picture type and the number of fixations. But the two latter scientists did employ a different method in their studies than the authors mentioned previously.

The importance of eye movements can be summarized in the following five points:

1. Only certain image elements attract our interest.
2. The pattern for eye movements and fixations depends on what we wish to see or are told to see in a picture.
3. Informative parts of a picture attract more fixations than less informative parts.
4. Different kinds of pictures give rise to different kinds of fixations and intelligence and visual learning.
5. There is a positive correlation between the number of fixations and intelligence and visual learning.

Colour blindness

Colour blindness, or better still "anomalies of colour vision," is a condition in which certain colour distinctions cannot be made. Anomalies of colour vision is much more commonly observed among men than among women, with estimates ranging as high as 10% of the male population (Hartley, 1987; Ware, 2004).

Only 1% of the female population has anomalous colour vision. The 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.

Sensory data and information

Pashler (1995) remarked that attention is a common word in ordinary language as well as a name of a field of study. This causes misunderstandings. According to Pashler the concept of attention is part of what might be called a folk-psychological theory – that is, an informal set of propositions people rely on to explain their own and other people's daily experience and behaviour. Most present-day attention researchers work in the tradition sometimes called information-processing psychology. Their goal is not to characterise conscious experience per se, but rather to trace the flow of information among different representational systems in the brain.

However, the objective for this book is to provide a ground for design of better information materials. Thus the details of mental information-processing will not be addressed here. This section provides an "information design perspective" on attention. The information designer may help people to notice the important information. One of the first problems for the information designer is to gain the attention of people, and thereafter she or he has the continuing problem of holding their attention.

Attention is closely related to the subject of consciousness and entails selecting parts from all available sensory information, and from memorised information, for further mental processing. The process of attention is the control mechanism that determines which stimuli will be noticed and which will be ignored (Carlson, 1993). Attention determines which events we become conscious of. Attention can be considered as the activation of groups of cells in the reticular activating system in the brain stem.

The brain stem dates back to the reptilian era. It is the seat of our emotions. It regulates basic life functions, sending us survival messages in response to danger, out of the range of our rational understanding. Urbina (1994) defined attention (p. 111): "as a readiness on the part of the organism to perceive stimuli that surround it." Attention is never objective – it is always subjective. We direct our attention to what we happen to be interested in; to special sounds; to things that move; are large, bold, and clear; are new; have bright colour, an unusual shape, a distinct direction, or a good contrast; and that deviate from the surroundings or from familiar patterns. We direct our attention to contents that arouse feelings and needs. Pashler (1995) noted that a task that is given full attention is accomplished quickly and efficiently. Ordinarily attention is under the control of our "will." However, external stimuli that are intense, novel, or significant may sometimes grab our attention and we turn toward the stimulus. If, however, the stimulus is repeated or continuous, the response will diminish. Tasks that initially required full attention may become so automatic that they can later be combined with other activities.

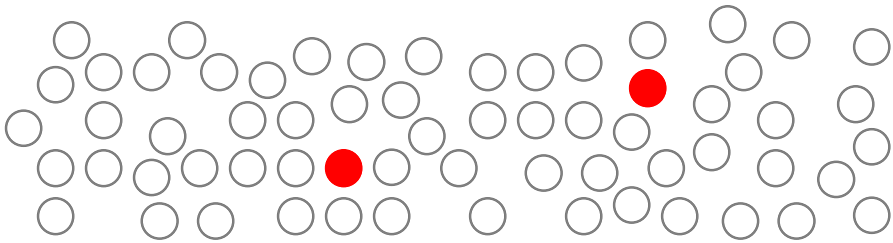
Magicians have learned the production of entertaining illusions. Tufte (1997) noted that magic is to engage in disinformation design. Magicians know how to direct the attention of the audience away from their conjuring tricks.

In any given situation there are always far more stimuli than we can ever notice and transfer to the short-term memory. We have to select the data and the information we want to see or hear and we ignore the rest. Most stimuli remain unknown, unseen, and unheard of. For Stern and Robinson (1994) this selection of sensory data is the first part of perception. However, many researchers see this selection as attention. Winn (1993) discussed the problem at what point sensory data become information. He wrote (p. 58):

> At what point do sensory data become information? Opinions on this have varied. On the one hand, Gibson (1979) has proposed that information exists in the environment, in the very light that enters our eyes. All humans have to do is pick it up and use it. Others have claimed that nothing can make any sense to us at all until it has been processed, top-down, by conscious attention; even that which we perceive in the first place is determined by what we know and therefore expect to perceive (Neisser, 1976). Recent research suggests a middle ground. While existing knowledge and attentive processing are important for recognition, identification, and so on, a great deal of organizing goes on preattentively. This means that conscious attentional processes are given data to work with that already have an organization that can predispose the perceiver toward particular interpretations.

For the message designer the main concern may be to find ways to influence the audience to really attend to their information materials. The efficacy of the attention process is measured by the advantage that attended tasks have over unattended tasks. It is also measured by the ability to resist distraction.

Attention plays an important role in memory. By exerting control over the information that reaches the short-term memory, it determines what information ultimately becomes stored in our *explicit memory*, or *declarative memory* (Carlson, 1993; Pines, 1986). This is the memory for facts, the memory of which we are aware. We know that we have learned something, and we can discuss this with other people. However, the storage of information in our implicit, or procedural memory does not require conscious attention. This is the memory for skills. It is our unconscious memory that is capable of controlling rather complex behaviours.



There are many stimuli. Among all the different stimuli we only attend to a few (here red). We ignore most of them.

Attention qualities

The literature on attention and perception is vast and it ranges from fine-grained psycho-physiological work on pre-attentive processes to the more general study of the perception and interpretation of illustration, text, and speech. One of the first problems for the information designer is to gain the attention of people, and thereafter she or he has the continuing problem of holding their attention.

Attention time span

An "attention time span" is the length of time a subject can focus on an object or a topic. Our attention will usually not last for long. Any information material and any presentation must constantly redraw the attention to hold the interest of the viewer. A presentation may hold the viewer's attention when the rhythm, layout, and pace are not predictable and boring. Ormrod (1989) pointed out that as children grow, their attention spans grow with them. They can concentrate on tasks for longer periods of time, and can more easily “block out” objects and events that are irrelevant to a task at hand. Young children may choose to pay attention either to a 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 (Pettersson, 1989).

When people turn on their television set they might not be interested in the programme. In Japan, television-viewing habits were recorded for participants in the Hi-OVIS project (Matsushita, 1988). During the first 30 seconds, people sometimes switched between 15–20 different channels. Thus, people only spent one to two seconds viewing the television image and deciding if the programme was interesting or not. Viewers did not take the time to actually listen to the sound. Their decisions were based on the pictorial style and the contents. According to Biederman (1995) people can usually interpret the meaning of a novel scene on television from a 100-millisecond exposure to it.

Moving pictures in movies and television can trigger associations and easily influence emotions and attitudes (Zakia, 1985). Commissioned by the Director's Guild in honour of its 50th anniversary in 1986, the film Precious Images was a gift to the American movie audiences. This short consists of a 6.5-minute assemblage of classic moments from 469 favourite movies. Some moments linger for a few seconds but many are as short as eight frames (1/3 of a second), averaging 20 frames (less than a second). It is a strange experience to see this film. The carefully chosen images retain their meaning and emotional impact, and trigger your memory. However, in my view you need to see the film several times in order to fully appreciate it.

Contrast, graphics, shading, split screens, text, voiceover narration and zoom lens movements are tools to emphasize important details within moving pictures (Leshin, Pollock, and Reigeluth, 1992).

When people get new messages they immediately begin to interpret their meanings (Andersson, 2009). Web designers have only 50 milliseconds to make a good first impression (Lindgaard et al., 2006). Thus it is important how the content is presented.

Attention to 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. Although full colour photographs increase the costs, publishers of textbooks should make the number of such books more available to primary audiences (Ramsey, 1989).

Fleming and Levie (1978) noted that in visual displays containing several figures of one colour or one shape, a figure of a different colour or a different shape attracts our attention. Ibison (1952), Rudisill (1952), Dwyer (1971), and Spangenberg (1976) all claim that even if colour is not adding any important information to an image, it may still contribute to better learning because the interest may increase, and learners may pay attention to the image. A black and white picture represents reality in a different way than colour pictures. In black and white, all colours are transformed 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.

Attention to movement

As previously noted our peripheral vision is especially sensitive to movement and brightness, both highly relevant to the detection of any approaching danger. According to Fleming and Levie (1978) this pre-attentive vision provides a global, holistic view of the visual field in which figures are separated from each other. Movement or change in a picture or in an event attracts our attention and therefore causes many eye fixations. Hubel and Wiesel (1962) found that many sensory cells in vision responded only very weakly to uniform light but very vigorously to changes in light intensity. This principle also applies to other sensory cells, i.e., the cells respond primarily to change. Sensory cells are also quickly exhausted.

There seem to be different degrees of efficiency of attention in different situations. The context in which a visual message, the actual content, is presented is important for the way the message is perceived. When certain elements are in motion and others are stationary, the moving elements will be perceived as figure elements, and stationary ones will be perceived as ground elements (Lidwell et al., 2010, p. 50). For example, the context may consist of music, other visuals, sound effects, speech, and often-printed text. When we view a film or a television programme our attention is on either the image or on the sound. Image and sound cannot be the "figure" at the same time. 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, away from the surrounding stills. The surrounding stills become the ground. It is impossible for viewers not to be influenced by the movement. The fact that one must select information implies that there are limits to the ability to perceive, think, or do several things at once.

Acuity falls rapidly outside of the fovea. However, some information can be processed from peripheral vision. The gist of a picture or of an event can be understood after only a few eye fixations. Gibson (1966), Moray (1970), and many of their successors (e.g., Edwards and Coolkasian, 1974) feel that movements detected in peripheral parts of our visual field automatically cause the eyeball to shift position to permit fixation and full attention of these movements. Animation is common in several media, like video, computer games and on the Internet. The movement is powerful and attracts our attention (Ormrod, 1989). 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.

Attention to novelty

Fleming and Levie (1978) and Ormrod (1989) noted that novelty and whatever stands in contrast to immediate past experience or to life-long experience grabs our attention. Something unusual will capture our attention almost every time. Attention is not necessarily drawn to the excessively loud, bright, or extraordinary, only to what is quantitatively different from what has been attended to previously. Thus, attention is drawn to changes. Fleming and Levie (1978) argued that in directing our attention, we seek a balance between novelty and familiarity, between complexity and simplicity, between uncertainty and certainty. Familiarity in excess produces boredom, while novelty in excess produces anxiety.

The competition for our attention is usually very fierce in advertising and in propaganda. In accordance with Key (1977), the average adult in the USA was exposed to over 500 advertising messages daily in 1977, of which he or she consciously perceived around 75. Now, there are even more messages. Weilenman (1999) reported that every person in Stockholm, Sweden, is exposed to over 2 000 advertising messages daily in 1999. According to Norén (1999) the figure is between 3 000 and 4 000. These authors did not report on how many messages people actually pay attention to.

Moriarty (1991, p. 5) sees an advertisement as a conversation with a customer about a product. "It gets attention, it provides information, it tries to make a point, and it encourages you to buy, try, or do something. It tries to create some kind of response or reaction. It speaks to the heart as well as the head." Advertising is also a form of mass-communication, which is much more complex than a regular conversation.

Advertisements in newspapers, and advertising flyers, must be noticed otherwise they are useless. Here, unusual typefaces can be useful. In these situations the graphical form should stimulate attention, entice the reader to look at the headings and pictures and then actually begin reading the text. Since there are over 60,000 different typefaces (with still more being introduced), it is easy to combine them in many ways (Mijksenaar, 1997). Most of these typefaces are, however, of limited value. Usually only a very few typefaces are needed in information materials.

Attention to information sets

The intended message may be hidden within verbal or visual puns, within metaphors, satires, parodies, or within humour. In these cases, designers break the traditional rules or guidelines of instructional message design. It might also be possible to deliberately use the unexpected to attract attention to instructional materials. Mayer (1993a) stated that (p. 258-259):

> The first cognitive prerequisite for meaningful learning is that the learner pay attention to the relevant information. To accomplish this goal, the text must actually contain potentially relevant information; the instructional designer must successfully employ a procedure for identifying the relevant information; and the instructional designer must effectively draw the learner’s attention to the relevant information.

So message designers can make important contributions to the attention of relevant information.

Attention to text

Winn (1993) noted that in text, attention is drawn to words or passages that stand in contrast to the rest of the body of the text.

Readers rarely, if ever, begin at the beginning and read straight through a text all the way 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.

The reading procedure is of great importance to the reader's capacity for understanding a text (Gunnarsson, 1982). In “normal reading,” we direct our attention towards how we shall interpret the meaning of a sentence. Studying the syntax becomes subordinate to orienting our thoughts amid the semantic and pragmatic relationships that form the text's warp and woof. Text comprehension is a constructive process, in which the readers build their perception of the whole by integrating the text with their own experiences.

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 structure of a text should be as clear as possible. *Internal text structure* is built into the text itself. *External text structure* relates to the embedded strategies that focus a learner's attention on particular parts of the text (Jonassen & Kirschener, 1982). Headings should always be relevant and identify the subject matter. The purposes of headings are to attract the attention of the readers, make the subject matter readily apparent, and indicate the relative importance of items. Jonassen (1982) noted that the headings on different hierarchic levels will provide the readers with reference points and help them cognitively organise information for better retention and recall.

Attention to pictures

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 authors have suggested various roles, functions, objectives and purposes for the use of illustrations – often without a great deal of evidence to support their suggestions.

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 he had expected.

Vogel, Dickson and Lehman (1986) showed that visual presentation support is persuasive. There is a *picture facilitating effect*. In a study 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 pictures that are used is an important variable in reading comprehension (Levin, Anglin & Carney, 1987). However, unfortunately this becomes less important in reality since most students do not attend to the visuals at all. Many pictures in textbooks obviously remain "unseen" (Reinking, 1986; Weidenmann, 1989; Pettersson, 1990; Peeck, 1993, 1994). Neither teachers, nor students attend to these pictures.

Nelson-Knupfer and Stock-McIsaac (1992) studied the effects of grey shades in instructional materials. Their results indicated that no group of subjects remembered very much of the graphics at all. Along with similar reading speed between the groups, the results supported earlier claims that readers do not really pay attention to visuals used in text.

With respect to graphic design of statistical graphics Tufte (1983) concluded that (p. 87):

> Graphical competence demands three quite different skills: 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.

Later, Tufte argued (1997, p. 48) that good design brings absolute attention to data.

Attention to symbols

Any warning, and any symbol, must attract attention and be readily understood by the intended audience, the persons who need the information (Dewar and Arthur, 1999). The message must be legible at the appropriate distance, and must often be legible when seen for a short period of time under bad lighting conditions. A driver on a highway may only have a second or two to read a signpost. Then the message in the warning must be mentally processed and understood correctly. The action to be taken should be immediately obvious.

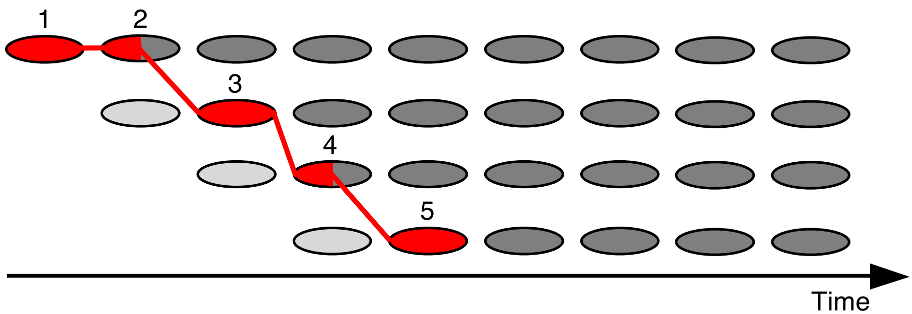
Furthermore the message in the warning must be able to motivate the intended receivers to comply with the desired behaviour (Wogalter, 1999). Here, colour may be combined with shape and position.

Attention to layout

See the section *Emphasis* in book 3 *Image Design* for emphasis in pictures and symbols, and the section *Providing emphasis* in book 4 *Graphic Design* for emphasis in text, typography and layout.

Attention to oral communication

Many teachers spend most of their time in the classrooms talking to their classes (Ferrington, 1994; Gustafsson, 1980a, 1980b; Pettersson et al., 1993; Sigurgeirsson, 1990). It appears that teachers generally teach the way they were taught, following the traditional approach to education, providing prepackaged information to students. No doubt, the lecture method has been the most common method of instruction in western education for centuries. In its early forms, the lecture method was a practised art form, a form of theatrical performance designed to grab and to hold the attention of the students.



In this model a presenter attracts attention 1), and holds it 2) for a while (red). However, another stimulus 3) grabs the attention of the viewer/listener, who is further distracted 4) by something new. Then it is hard for the presenter to gain the interest of the viewer, who again 5) will attend to something else than the presentation. It is easy to loose an audience, and hard to get it back. Unattended stimuli are white in the picture.

Until the advent of low-cost books, the lecture method was actually the most economical method of transmitting information. However, modern teachers are usually not selected for their lecturing and theatrical skills. Thus the lecture method is under frequent attack.

Cochran (1987) concluded that humans couldn't transfer ideas whole and intact from one person to another. Human communication depends upon an interactive series of successive approximations presented in metaphors. She found "languaging" useful in directing attention to the actions of people as they share their own ideas, listen to others, or learn from technologically produced sights and sounds. An oral presentation may consist solely of speech, but this is usually not sufficient for achieving the best possible communications.

Various media may be used in oral communication in order to improve attention and perception. Here attention can be appealed to directly through the use of verbal imperatives (look, listen, notice, observe, see) as well as by asking questions and posing problems to the audience. Such guides to learner attention are very useful in increasing the effectiveness of illustrations (Kahneman, 1973).

Attention theories

There are several attention models and attention theories. Clements (1984) concluded: "the attentional process is relatively diffuse" (p. 146). Associationists, behaviourists, Gestalt psychologists, and psychoanalytic theorists tended to neglect attention in their postulations. Since the mid-1950s, however, there has been a lot of interest in attention. Modern Russian psychologists studied the orienting reflex or orienting response, which consists of a cluster of physiological changes in the surroundings (Urbina, 1994).

This field of knowledge includes two areas of knowledge: 1) capacity theories, and 2) resource models.

Capacity theories

Attention makes us receptive to specific data and information in our environment (external context). Among the thousands of stimuli in the external context we only feel, hear, see, smell, taste, or "pay attention to" one stimulus at a time. Attention is direct, distinct, and sudden. The sequential flow of attention to the parts of a message is determined by the sequence in which data and information is presented to us. New impressions are dependent on and interpreted against the background of our previous experience, learning, and memory, i.e. our *frame of reference*.

When we attend to something we select that data or information for further processing. Attention can be considered as the activation of groups of brain cells. In any given situation there are always far more stimuli than we can ever notice and transfer to the short-term memory. We have to select the data and the information we want to see or hear and we ignore the rest. Most stimuli remain unknown, unseen, and unheard of.

Filter theory

Broadbent (1958) studied selectivity of attention and he proposed a *filter theory*. According to this theory we are not able to attend to more than one stimulus at a time. Broadbent suggested that while a large amount of sensory information can be absorbed at one time, a selective filter (the attention mechanism) reduces the input from one source while that from another source is being analysed by the brain. Here attention is a limited capacity channel that determines the serial processing of the perceptual system.

Pertinent stimuli theory

We can pay attention to the content of a message, to the execution of that message, to the context in which the message is presented, and to the actual format or medium that carries the message. All of these factors may influence our attention.

The filter theory did not allow for the influence of long-term memory or the meaning of the stimulus. However, subsequent experiments showed that the content of an unattended message may be perceived if it is relevant. Semantic characteristics of the stimulus affect attention. Deutsch and Deutsch (1963), and Norman (1967) suggested that we analyse all inputs but only attend to pertinent stimuli.

Pre-attentive processing theory
Certain simple shapes or colours "pop out" from their surroundings (Ware, 2000). This is called "pre-attentive processing." Ware writes (p. 163): "In essence, pre-attentive processing determines what visual objects are offered up to our attention." The features that are pre-attentively processed can be organised into categories based on colour, form, motion, and spatial position.

In information materials graphic form, pictures, sound, and words compete for our attention. Information materials must get attention, and maintain attention. In order to facilitate attention the information designer should use pictures that are interesting enough for the intended audience. It is a good idea to use different types of visuals, and provide pictures of the human figure, in particular pictures of the face.

Resource models
There are several *attention resource models*, such as a two-process theory, a sudden attention theory, an arousal theory, a multiple resource theory, a misdirecting attention theory, a location and shape theory, an attention time span theory, a colour attention theory, a brightness and movement theory, and a novelty attention theory.

Two-process theory
Neisser (1967) outlined a two-process theory that made attention a matter of degree. Properties of the stimuli as well as properties of semantic factors play a role in attention. Neisser argued for a constructive view of cognition in which perception is shaped by existing knowledge. Thus attention is influenced by experience and knowledge.

Sudden attention theory
Kahneman (1973) presented a model of attention with deliberate allocation of mental resources. In addition to unconscious processes, attention can be consciously focused. One example of this is our sudden attention when you hear someone in a crowd mention your own name. The model also introduced the idea of attention as a skill that can be improved. This skill may be used for improvement of our learning processes.

Arousal theory
Eysenck (1982) examined the relationship between attention and arousal and concluded that there are two types of arousal: one passive and general system that can raise or lower the overall level of attention, and another specific, compensatory system that allows attention to be focused on certain tasks.

Multiple resource theory
Wickens (1980, 1984, 1991), and Klapp and Netick (1988) suggested a multiple resource model of attention and further processing. Resource models based on individually allocated pools of resources have been developed to explain the effects of structural alteration and time sharing that cannot be effectively explained by other attention models.

Misdirecting attention theory

According to Sweller et al. (1990) all cognitive tasks place demands on a pool of limited cognitive resources. When a task imposes a heavy load on the cognitive system, it will in turn interfere with learning by misdirecting attention and limiting remaining resources that are necessary for construction of knowledge. Presentation of content may be designed to avoid cognitive overload (Mayer & Moreno, 2003; Sweller, 1994). Harber (1983) and Rose (1986) found that pictures distracted the attention of low-ability learners from the text, and reading comprehension was low.

Location and shape theory

Carlson (1993) concluded that studies with visually presented information indicate that attention can focus on *location* or on *shape*. We can pay attention to particular objects or to stimuli that occur in a particular place. This is especially important for those who design warnings and symbols. Irregular and unpredictable shapes dominate basic and regular shapes. Such 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.

Attention and message design

We are almost always paying attention to something, whether it is information in our environment or information already in our heads. Paying attention requires mental effort. Usually we can only attend to one thing at a time. Fleming and Levie (1978) stated that one of the message designer's first problems is to gain the attention of the audience, and thereafter she or he has the continuing problem of holding the attention.

A general attending is often insufficient, for attention must be directed narrowly and precisely to critical aspects of the subject matter. Winn (1993) argued that a great deal of perceptual organisation occurs pre-attentively, not under cognitive control. The way a message is organised will have an important effect on the way the perceptual system structures what it detects and the perceiver will not be aware of how that information is interpreted.

Facilitating attention to colour

To some extent colour is a language of its own. Colour creates instant impact and it becomes a vital part of the first impression. Therefore colours can be used as effective signals in information design. In order for colour to be used as efficient cues and attract attention to, or attract attention within information materials the information designer can:

- Consider embedded meanings of different colours when using colours to accent words in a text (Hartley, 1987).
- The number of colour codes must be limited and they must always be explained (Pettersson, 1989, 1993). Improper use of colour can be distracting, fatiguing, and upsetting and it can actually produce negative results.
- Use bright and bold bold and bright colours to capture attention (Ormrod, 1989).
- Use colour and grey scale to influence the perception of size. Open and light forms are perceived as being larger than closed and darker forms of the same shape (Winn, 1993).
- Use colour as an accenting device (Christ, 1975; Dwyer, 1978; Katzman & Nyenhuis, 1972; Lamberski, 1972; Whiteside and Blohm, 1985; Winn, 1993; Wogalter, 1999).

- Use colour coding as an accenting device to improve attention in documents, in signs and in symbols (Bradshaw, 2003; Christ, 1975; Dwyer, 1978; Hannafin and Peck, 1988; Katzman & Nyenhuis, 1972; Lamberski, 1972; Pettersson, 1989, 1993; Whiteside and Blohm, 1985; Winn, 1993; Wogalter, 1999).
- Use colour to clarify the structure of a text. Certain parts of the text may be printed with colours or printed on top of backgrounds in different colours (Pettersson, 1989, 1993).
- Use colour to enhance attention to a visual message (Dwyer, 1978, 1985).
- Use full colour photographs in textbooks for primary audiences (Ramsey, 1989).

Facilitating attention to text

In order to attract and hold attention to texts in information materials the message designer can:

- Create a positive impression and give courseware a comfortable image to gain and maintain learner attention and to build confidence (Keller & Burkman, 1993).
- Divide the text into sections and subsections to avoid too large masses of text (Jonassen & Kirschener, 1982).
- Do not overuse accenting techniques in text. They may loose their meanings (Bausell & Jenkins 1987; Benson, 1985; Dwyer, 1978; Hartley, Bartlett & Branthwaite 1980;).
- Help the reader to control his or her cognitive processes during learning to encourage readers to pay attention to relevant information (Mayer, 1993b).
- Make the key words red or underline them (Fleming & Levie, 1978).

- Make the structure of a text as clear as possible (Jonassen & Kirschener, 1982).
- Set text bold enough (Mayer, 1993a; Wileman, 1993).
- Set text large enough (Ormrod, 1989; Wileman, 1993).
- Use adjunct questions to emphasise relevant information (Mayer, 1993a).
- Use blinking and flashing text on a computer screen as an accenting technique (Rambally & Rambally, 1987).
- Use headings to make the subject matter readily apparent, and indicate the relative importance of different items in the document (Cisotto and Boscolo, 1995; Jonassen, 1982; Mayer, 1993a).
- Use headings, italics, boldface, or a larger font to highlight the relevant information (Mayer, 1993a).
- Use relevant headings to identify the subject matter (Jonassen, (1982).
- Use space and the actual placement of a heading to enhance the hierarchic structure (Jonassen, 1982).
- Use statements of instructional objectives to emphasise relevant information (Mayer, 1993a).
- Use the unexpected to attract attention to instructional materials (Mayer, 1993a).
- Use white space between portions of a text as a cue to the learners that a new section follows (Waller, 1987).
- Use words or passages that stand in contrast to the rest of the body of the text (Winn, 1993).

Facilitating attention to pictures

A large number of researchers propose that pictures may be used to *attract attention, gain attention, get attention, hold attention* and *maintain attention* to a given material or a given subject. (See the section *Functions of visuals* in book 3 *Image design.*)

The receiver must see or rather "discover" each picture and actually read the message in an active and selective way. The information designer can:

- Exaggerate the shape of a known person or object, as in caricature or cartoons to draw attention to the whole figure or to particular relevant features of it (Fleming & Levie, 1978).
- Instruct the readers to really use the pictures (Hannus, 1996; Peeck, 1993, 1994; Pettersson, 1990, 1993; Reinking, 1986; Weidenmann, 1989).
- Make the most important part of the subject large and clear (Ormrod, 1989).
- Pictures must be in colour so they resemble the real world (White, 1987).
- Put pictures on odd-numbered pages. They attract more attention than pictures on even pages (Pettersson, 1989, 1993).
- Use different types of visuals (Gayer, 1992).
- Use captions to direct attention within pictures (Winn, 1993).
- Use picture elements that are bold enough to see (Wileman, 1993).
- Use pictures of the human figure, in particular the face. Our faces will get maximum attention in images (Goldsmith, 1984; Pettersson, 2002a).
- Use several kinds of visual types, such as diagrams, drawings, photos to increase interest in a material (Pettersson, 1989, 1993).

- Write a caption for each picture (Bernard, 1990; Pettersson, 1993)

Facilitating attention to symbols

The receiver must be able to see or rather “discover” symbols. This is especially true for different kinds of warning signs. Sometimes the information designer may be able to influence these possibilities:

- Combine colour with shape and position (Wogalter, 1999).
- Make warning signs of high contrast relative to their background (Barlow & Wogalter, 1993).
- Provide warning signs with adequate reflectance and good lighting (Sanders & McCormick, 1993).
- Provide warning signs with properties that allow them to be seen in degraded conditions such as low illumination, smoke, or fog (Lerner & Collins, 1983).
- Put warning signs close to the hazard (Wogalter, 1999).
- Red, orange and yellow are commonly used in warnings to indicate different levels of hazard (Wogalter, 1999). Complementary colours contrast and provide a warm – cool effect.
- The choice of colour should also depend on the environment in which the warning is placed (Young, 1991).
- Use a combination of pictographs and words in complex warning messages (Dewar & Arthur, 1999).
- Use a signal word such as “Danger”; a description of the hazard such as “Shallow water”; a description of the consequences that could occur; the specific actions that should or should not be done, such as “No diving” (Wogalter, 1999).

- Use arrows and lines in various colours for wayshowing (Mollerup, 2005).
- Use arrows and lines in various colours to draw attention within information materials (Beck 1984; Lamberski & Dwyer, 1983; Pettersson, 1993).
- Use clear and distinct symbols for warnings (Dewar & Arthur, 1999).
- Use clear and distinct symbols for wayshowing (Mollerup, 2005).
- Use large, legible bold-faced alphanumeric characters on warning signs (Wogalter, 1999).

Facilitating attention to layout

Graphic design is a tool with which we can manipulate the raw materials – words, empty space, illustrations, colour, paper and ink, and the final number of pages – to achieve the best possible communications between people. Layout and typography should be transparent and not stick out and cause any specific attention in information materials. However, sometimes, it may be important to direct attention to specific parts within information materials. In such cases the information designer can:

- Provide a good contrast between figure and ground (Wileman, 1993)
- Put pictures as close to the relevant text as possible (Benson, 1985; Braden, 1983; Haber & Hershenson, 1980; Hartley & Burnhill, 1977a; MacDonald-Ross, 1977; Mayer & Sims, 1994; Mayer, 1993; Mayer & Sims, 1994; Mayer et al 1995; Moreno & Mayer, 2000; Pettersson, 1989, 1993; Wright, 1982).

- Put pictures between the appropriate paragraphs in the text to get maximum impact (Pettersson, 1989, 1993).
- Select font, or fonts, based on the audience and the purpose of the document (Benson, 1985).
- Set headings in different type versions to aid comprehension of the text content (Jonassen, 1982; Mayer, 1993a).
- Use “bleed” (covering the entire page, with no margins) creatively to expand the impact of attention-getting images (White, 1987).
- Use arrows in various colours in order to draw attention to a picture (Beck 1984; Goldsmith, 1984; Lamberski & Dwyer, 1983; Pettersson, 1993).
- Use bullets, arrows, icons, underlining, margin notes, repetition, and/or white space to highlight the relevant information (Mayer, 1993a).
- Use combinations of dark and bright, large and small, round and square, to sharpen meaning (Pettersson, 1993).
- Use highlighting techniques to enhance relevant information (Pettersson, 2003).
- Use imbalance within a picture or within a text (Fleming & Levie, 1978).
- Use captions to direct attention and interest within pictures (Pettersson, 2003).
- Use lines in various colours in order to draw attention to a picture or to specific picture elements (Beck 1984; Goldsmith, 1984; Lamberski and Dwyer, 1983; Pettersson, 1993).
- Use pictures that are tilted on the page to attract attention (White, 1987).
- Use the composition to direct the viewers (Wileman, 1993).
- Use unexpected, irregular, and unstable design to attract attention (Fleming & Levie, 1978, 1993).

Perception

Traditionally experience is divided into two categories: *sensation* and *perception*. Sensation is thought to be a lower-level function. It is often defined as the awareness of simple properties of stimuli, such as brightness, coldness, colour, sweetness, or warmth. Perception is thought to be a function of higher-order areas of the brain. It is the awareness of complex characteristics of stimuli.

According to tradition we have five senses, but in fact we have more. Sensory organs jointly constitute a perceptual system that, in a natural environment, collects an enormous amount of superfluous data about our environment. In a natural environment, the sensory system normally supplies us with exhaustive, unambiguous data about events occurring there. Perception is the second step in the *Learning Helix*.

We are often unaware of the sensory channel(s) supplying us with information. We are merely aware of the external events, events that appear to be absolutely real and unambiguous. But in unnatural, artificial surroundings, the brain often "translates" sensory stimuli, in an attempt to relate them to its stored information, memories, about more familiar places, events, and times.

Each eye contains about one million afferent nerve fibres. Each ear has about 30,000. Thus, the eyes and ears are capable of receiving vast quantities of information. However, it is impossible (and undesirable) for us to be aware of everything happening around us. At any given moment, the eye may contain 2 500 000 bits of information. Laboratory studies have shown that a subject is able to perceive three to six different, simple graphical symbols per second when the subject's concentration is devoted solely to this task. It is easier to perceive large and clear symbols than small, blurred symbols.

Perception principles

Fleming and Levie (1978) noted over 50 principles, and Winn (1993) listed more than 75 principles related to perception. While intended for the instructional designer, these principles are also useful to the individual learners. The goal for these lists of principles is to create better and more accurate perception, avoid misperceptions, and help instructional designers to create different kinds of messages.

In view of our limited capacity for handling simultaneous information (Miller, 1956), it is important to find out which factors determine the parts of the available information that will be processed. Which stimuli do we select and why? When we first look at a visual, we only see what is necessary to perceive and identify objects and events in a reasonable and meaningful manner. This is Gibson's "principle of economy" (Gibson, 1966).

We only pay attention to the things that affect us emotionally (Lanners, 1973). Everything else is ignored. When we look at a picture, we first discover the cues we already know. We probably become more easily familiar with simple patterns than with complex patterns. Closed shapes are preferred to open shapes and fields. Once we have identified a few well-known shapes, we sometimes feel that we have "seen everything" and may miss some valuable information.

Selection and order

We have so much information coming from the outside world that we cannot pay attention to all of it. In the torrent of information that bombards us, we have to select the information we want to see or hear and we ignore the rest of the information. As previously noted Stern and Robinson (1994) regard “selection of sensory data” as the first step of perception. However, “selection of data” may also be seen as a part of “attention.” When we attend to something we select that information for further processing.

The perception process is often assumed to consist of two stages or levels. Information processing is automatic, unconscious, tentative, fast, rough, and parallel in the first stage (Sinatra, 1986). It comprises all kinds of analysis, from physiological to cognitive processes. Different properties of a stimulus are identified simultaneously. Often one analysis is sufficient. The second stage of the information analysis is conscious, it demands attention, and it is detailed and sequential. Various hypotheses about a stimulus are weighed against one another, and tested. Information processing is more definite at this level.

Surfaces of shapes

According to Nakayama et al. (1995) surfaces of shapes constitute the only visually accessible aspects of our world. We cannot, for example, obtain visual information from the interior parts of ordinary objects. However, often object surfaces occlude other surfaces. Nakayama et al. argued that the visual system must develop an internal representation of the scene as a set of surfaces as a prerequisite for further mental analysis. They argued that image-based representations are insufficient bases for higher-level vision. Nakayama et al. showed that adopting a few simple rules makes surface representation comprehensible (p. 10).

Rule 1. When image regions corresponding to different surfaces meet, only one region can “own” the border between them.

Rule 2. Under conditions of surface opacity, a border is owned by the region that is coded as being in front.

Rule 3. A region that does not own a border is effectively unbounded. Unbounded regions can connect to other unbounded regions to form larger surfaces completing behind.

Perception is subjective

Perception is not an absolute and objective process. It is subjective, and varies as a result of a number of factors, like the learner's current cultural and social status, the time and stage of his or her development, mood, experience, memory, and other cognitive processes. All this sets a "frame of reference" for the perception process. Some of our sensory impressions give rise to "garbage" and some to learning. The cognitive variables exert an influence on subsequent perceptions and they may also evoke inner perceptions and inner imagery.

Individuals differ in the ways that they perceive any given stimulus. One person may perceive a stimulus and quickly assimilate it. Another person may not assimilate that stimulus at all. Human perception is only sensitive to changes in stimulation. You actually perceive less than all you see and hear, and much information is never used. At the same time you may perceive more than you see and hear. You may believe that you see and hear things that are not there. Your brain fills in missing information. Accurate identification can be made from the correct perception of just a few parts.

The perception system strives to obtain clarity. If the system arrives at clarity, then clarity serves as reinforcement, a reward. So, our perception of a text or of any image depends on our previous experience, our mood, other pictures, texts and sound, as well as our personal interests. When we look at a visual, we also "see" different details in the visual on different occasions. Consequently, a highly "saturated," information-packed message, like a picture, may have something new to offer even after having been viewed many times.

Perception theories

We live in a tree-dimensional world, full of sounds, fragrances and odours, light and shadows, events and objects resting on various surfaces. As visual creatures we rely on reflected light to obtain information from the visual world. The concept "perception" is a collective designation for the different processes in which an organism obtains data about the outside world. Perception is the organizing and analyzing of the data that we pay attention to.

This field of knowledge includes four areas of knowledge: 1) clarity theory, 2) figure and ground theory, 3) Gestalt theories, and 4) affordance theories.

Clarity theory

We unconsciously make a constant effort to create some order in the impulses. We organize and analyze data that we have paid attention to. Perception of two- or three-dimensional representations entails fast, holistic, parallel, and simultaneous processing (Gazzaniga, 1967; Sperry, 1973, 1982). We rely on our senses to provide us with data about the outside world. Points, lines, areas, symbols, colours, tones, noise, heat, cold, touch, pressure, sound, visuals, text, are integrated in such a way that they can be interpreted as a meaningful whole.

We do not "see" patches of colours and shades of brightness. We look for, recognize patterns, and combine them into something meaningful. We perceive things, like books, cats, dogs, flowers, houses, people, and trees. We rely on our experiences, thoughts, and values to interpret, understand, and create meaning from what we hear, taste, touch, see, and smell.

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.

The perception system strives to obtain *clarity*. When the system arrives at clarity, then clarity serves as reinforcement, a reward. Thus an important principle for the designer is to improve *clarity* of any message (Fleming & Levie, 1978; Winn, 1993). The *main goal* in information design and instruction design should always be *clarity of communication* (Pettersson, 2013a). We should limit the content to what the intended audience needs, and emphasize what is most important. Pictures should be well worth reading for the intended audience.

Barry (1998) made a clear distinction between two *independent mind systems*, one that feels and one that thinks. This explains why images may speak to us holistically and emotionally. Data about some images are only emotionally processed. Other images are analysed. In *rational theory*, people weigh things equally and then consciously decide on truth or logic. In reality, however, emotional response comes first. Barrry concluded we begin to respond to the visual environment emotionally, below the level of or rational awareness, before we can critically analyze it. This makes it likely that much of cognition is actually rationalisation to make unconscious emotional response acceptable to the conscious mind.

I have presented a similar "dual view" (Pettersson, 1987) when I found that simple line drawings accompanied by various assignments caused very different reactions in subjects. It is obvious that the different assignments have caused perception and image interpretation on different cognitive levels.

Figure and ground theory

Perception is always organized. We perceptually construct relationships, groupings, objects, events, words, and people. We see dots, lines, areas, light, dark, etc., in an organized way. We see whole images rather than collections of parts. The whole is different from the sum of the parts. A number of psychologists view our attempts to establish order as an innate faculty carried out in accordance with certain "laws" or principles for display of information.

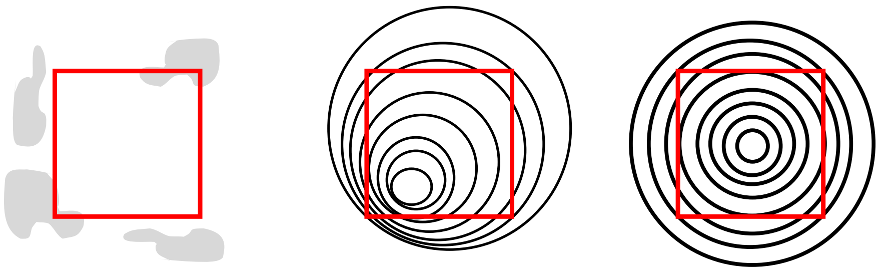
Figure/ground organization

Figure/ground perception is a fundamental aspect of field organization. The Danish psychologist and phenomenologist Edgar John Rubin (1886-1951) presented his work on figure/ground perception 1915/1921 (Palmer, 1999). This was before Max Wertheimer presented his *Gestalt laws* in Germany.

This work is also known as figure/ground articulation, figure/ground organization, figure and background principle, figure and ground principle, and as the theory of figure and ground.

According to this organization we select some elements in a picture as the *figure,* the object of interest. The remaining parts constitute the *ground* on which the figure rests. This is one of the simplest perceptual organizations. The visual system has a strong preference to ascribe the contour to just one of its border regions and to perceive the other side as part of a surface extending behind it (Palmer, 1999).

We perceive the figure as being in front of the ground, and the ground as being behind the figure. We might be tempted to view figure and ground as a relationship between just two levels (Schriver, 1997, p. 307). However, what serves as the ground in one relationship can serve as the figure in another relationship. The figure/ground organization is affected and influenced by several factors, such as: context, convexity, contrast, meaningfulness, motion, orientation, parallelism, size, and symmetry.



In the illustration to the left we easily recognize a square as a "figure" against the dotted background. In the other two illustrations, the properties of "figure and background" cannot be sharply distinguished. The three squares are of the same size, all with straight sides, but that is not how we perceive them. The distances between the squares are the same.

Reversible figures

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. We have all seen Rubin's vase, a reversible figure that is perceived as a vase *or* as two heads facing each other.

Sometimes it may be hard to distinguish between figure and ground. Then some structures will be perceived as reversible. Reality and what we see at any given moment will always be separated and different. We will perceive different things at different occasions, both with respect to reality and with respect to pictures. In some cases figure–ground articulation has apparently been based on experience (Peterson & Skow-Grant, 2003).

In their natural environment many animals are camouflaged with colour, spots, and stripes. Thus their shapes and boundaries are obscured. As long as these animals remain still they are well hidden because we cannot distinguish figure from background. This is especially true for the predators. Once the animals move their shapes may be perceived. Miller (2007, p. 11) noted that the animal kingdom is "filled with creatures whose colours and patterns help conceal and protect them."

The birth of modern military camouflage was a direct consequence of the invention of the aeroplane (Newark, 2007). Aircraft were initially used in the First World War for aerial reconnaissance. Their task was to spot enemy artillery, troops, and vehicles. Their own artillery could then direct their fire at these targets. All sides formed "camouflage units." Members of staff painted bold disruptive patterns on aircrafts, guns, and tanks. In France several prominent Cubist artists were working as "camoufleurs" at the front. Information design is the opposite to camouflage. There must be a good contrast between figure and ground in information design.

Gestalt theories

Early in the 20th century the three psychologists Max Wertheimer (1880–1943), Kurt Koffka (1886–1941) and Wolfgang Köhler (1887–1967) collaborated on the founding of a new holistic attitude toward psychology called *Gestalt psychology,* or

Gestalt theory. Wertheimer started his research on the gestalt principles of perceptual grouping already in 1910 (King, 2005). The *Gestalt principles* were introduced by Wertheimer (1922, 1923), and were further developed by Köhler (1929, 1947), Koffka (1935), and Metzger (1936/2006).

The German word *Gestalt* means form, pattern, or shape. The Gestalt psychologists believe that conscious experience must be viewed as a "whole," and cannot be analysed into its parts. This "whole," or "Gestalt," can be an image, a shape, or a thought. Feeling, hearing, and seeing, must be studied together in order to understand their relationships. The essential thesis in *Gestalt psychology* is that in perception *the whole is different from the sum of its parts* (Koffka, 1935; Köhler, 1929; Palmer, 1999; Wertheimer, 1923).

Each principle is supposed to function, as long as all other things are constant (Palmer, 1999). The need to process large numbers of small stimuli is reduced, and perception is faster. Elements that are far apart are perceived as separate objects. There are many Gestalt principles, but there is no definitive list of them (Todorović, 2008). The observations on which the "Gestalt theory" is based form a basic part of the graphic designer's craft knowledge (Waller, 1987).

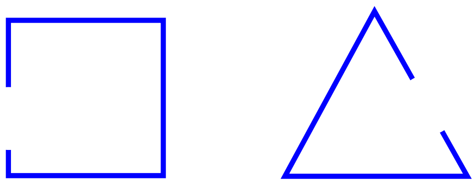
In literature all the Gestalt principles are often referred to as *Gestalt laws*. However, today we should only use the term *Gestalt principles* of perceptual grouping since they are considerably weaker than one would expect of scientific laws (Palmer, 1999).

Area principle

According to the *principle of area* we will interpret a small shape within a larger shape as the "figure," and the larger shape as the ground. Our ability to distinguish the boundaries of an image is usually very high. All elements in a visual should contribute to clarity, the visual should be meaningful to the intended audience.

Closure principle

The *closure principle* (*low of closure, natural law*, *theory of closure*) is based on our tendency to see complete figures even when the stimuli is incomplete. We fill in the missing parts and "close" the outline of the structure. There is always a need for our minds to reach a general understanding, and this is a key factor in cognitive organisation (Luchins and Luchins, 1959). We will extract meaning and reach conclusions.

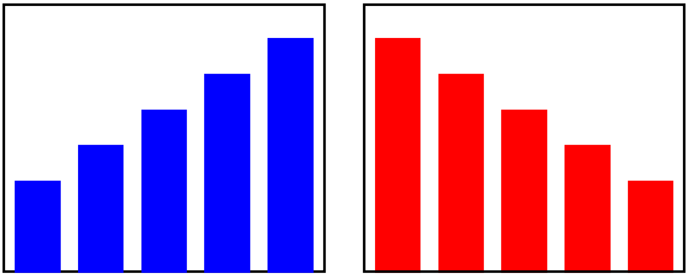


Our minds fill in missing details and make the best possible interpretation of any given stimulus. We perceive these figures as a square and a triangle.

Letters printed with damaged or broken type are typically seen as perfect or whole characters. The use of classical Swiss grid systems in layout is based on regular rows and columns. If a figure in an illustration is incomplete, our minds will fill in the missing parts and "closes" the outline of the figure.

Common fate principle

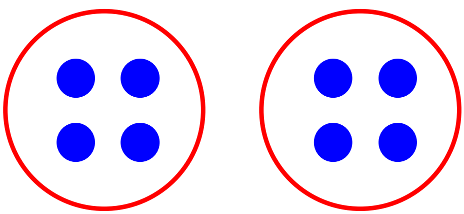
In accordance with the *common fate principle* (*law of common fate*) elements or objects that *move* in the same direction belong together and they are perceived as a collective entity. Objects that are grouped in a particular way will be expected to change in conformance with this grouping. When change does not follow this pattern, the change is difficult to process. We perceptually group lines that seem to be moving in the same direction. This is common in diagrams and in graphs.



In these two bar graphs all the bars have different heights. In the first case the bars are moving upward, and in the second example they are moving downward.

Common region principle

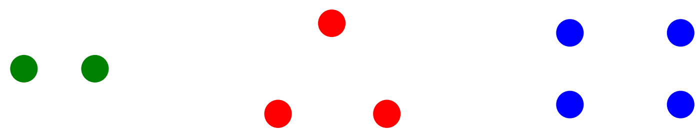
The *principle of common region* is based on our tendency to see elements or units that are enclosed by a boundary, such as a circle, as single units. We group such elements together (Horn, 1998, p. 76).



We have a tendency to see elements enclosed by a line as single units. Here we have two units of blue dots rather than eight blue dots.

Connectedness principle

A single dot on a paper has strong visual power to attract our attention. Two or more dots *connect*, and are capable of leading the eye. Dots create the illusion of lines and areas, or sometimes even volumes. The *principle of connectedness* states that elements that are connected by other elements tend to be grouped together.

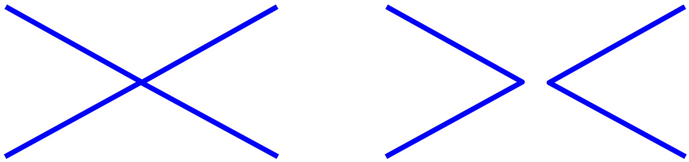


We easily make "wholes of units." Two dots suggest there is a line between them. Three dots suggest the existence of a triangle and four dots suggest a rectangle.

We have a tendency to see uniform, connected regions as single units. The region may be points, lines, or a more extended area (Horn, 1998, p. 76; Palmer, 1999, p. 260). This is generally how we perceive diagrams (Malamed, 2009, p.66). Perception is influenced by our expectations.

Continuity principle

When lines overlap or compete, emerging figures have good continuation. The most symmetrical and simplest figures constructed will be perceived. The *continuity principle* (*continuity law*, *good continuity*, *theory of direction*) refers to simplicity. We perceive a slow and gradual change in an auditory or in a visual stimulus as one single stimulus. It is easier to perceive a smooth continuation than an abrupt shift of direction.



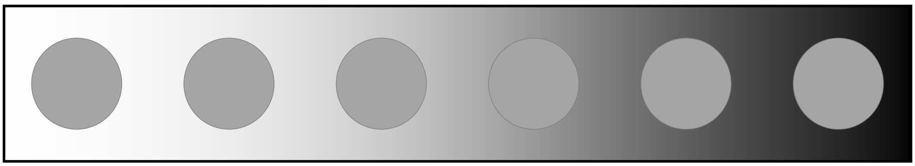
We perceive the pattern to the left as two lines crossing in the middle rather than as two (or even four) opposing angles joined together at their apexes. This is also referred to as “line of direction.”

Lines moving in the same direction belong together. Events that have a simple and natural relationship to one another also give the impression of being continuous and unbroken. Straight or curved lines tend to lead the eye along, and even beyond, the line. An arrow or a finger pointed at something leads your eye to it. Perception is selective. Elements that are aligned are grouped together, and integrated into perceptual wholes. It is easier for us to perceive a smooth continuation of a line than an abrupt shift of direction.

Contrast principle

In accordance with the *contrast principle* (*contrast law*) we tend to array impressions that form natural opposites in groups. Thereby the impressions are reinforcing one another. Contrast is the difference between the brightest and the dimmest parts of a picture, or of a text. Perception is always relative. A specific line seems to be long when it is compared with a shorter line, but it seems to be short when it is compared with a longer line.

A line (A) seems to be long when we compare it with a shorter line (B), but it seems short when we compare it with a longer line (C). Perception is relative.



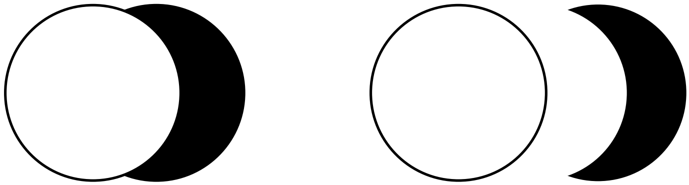
Our perception of one tone of grey will change when it is placed on a continuous tonal scale. Perception is relative.

Convexity principle

According to the *convexity principle* convex patterns will be perceived as figures.

Good form principle

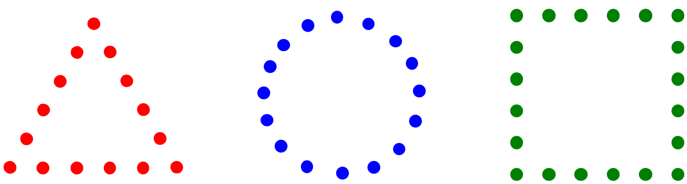
"Good figures" are closed and exhibit a continuous contour. A given contour can belong to only one of the two areas it encloses and shapes. According to the *good form principle* we have a tendency to perceptually group elements together if they form a pattern that is orderly, regular, and simple. This principle demonstrates that people eliminate complexity and unfamiliarity.



We see the left pattern as one circle partially overlapping another circle. This interpretation seems to be the natural one. But there are many possibilities. This is the principle of good form. Here our expectations influence the perception.

Grouping principle

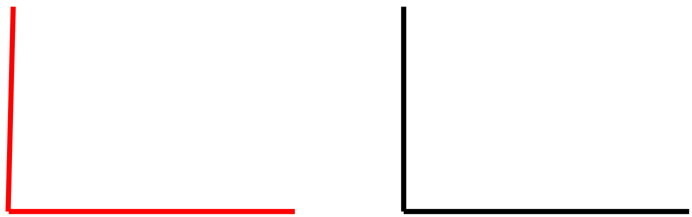
Most figures are defined by a boundary. However, according to he *principle of grouping* (*law of grouping*) we do not need a boundary for the perception of form or shape. When small elements are arranged in groups, we tend to perceive them as larger forms. This is similar to "closure." By grouping headings, paragraphs, illustrations, and captions the designer aids communication. The principles of common region, connectedness, proximity, similarity, symmetry all work together to evoke grouping.



Groups of smaller elements may be perceived as larger figures. Here small dots form a triangle, a circle, and a square.

Objective set principle

According to the *objective set principle* some phenomena are perceived more strongly than others. For example, two lines that almost form a right angle are perceived as a right angle. This refers to our perception tendency towards a stable group. Once perceptual units are seen as a group, perception will try to retain this group.



We perceive two lines that almost form a right angle (left) as a right angle (right).

Past experience principle

According to this *past experience principle* (*previous experience principle*) our new impressions are dependent on, and interpreted against the background of our previous experience, learning and knowledge. Our assessments and our experiences change over time and affect our way of associating. We sometimes only perceive what we want to perceive. It is easy to jump to the wrong conclusions. Messages that are contradictory often create more confusion than they provide help. A torrent of information bombards us from the outside world.

Proximity principle

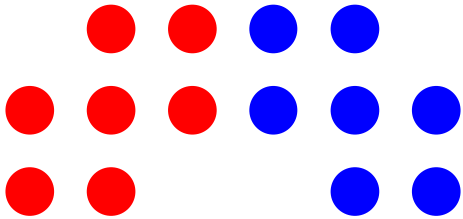
Spatial *proximity* is one of the most powerful organizing principles and one of the most useful in information and message design for perceptual organisation of data. In accordance with the *proximity principle* (*law of nearness, law of proximity*) we see individual elements but we will perceptually group events, objects, and units on the basis of their proximity to one another. Such elements "belong together" and they are processed together. The eye tends to be attracted to groups or clusters rather than to isolates. We can use space to group graphic components. Related data and elements should be put in close proximity to each other.

Spatial proximity is a powerful cue for perceptual organisation of data. There are eight individual black squares in this illustration, but we perceive them as four pairs of black squares. Spatial proximity was one of the first observations made by the Gestalt psychologists.

Similarity principle

According to the *similarity principle* (*law of similarity, theory of similarity*) we tend to perceive and group our impressions on the basis of their similarity. Events, objects, and units that resemble each other, and share similar characteristics and properties belong together. It can be qualities like brightness, colour, darkness, orientation, pattern, shape, size, texture, value, or other qualities.

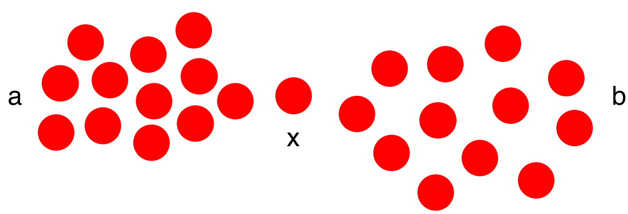
One black sheep in a flock of white sheep tends to be noticed. The similarity principle is one of the most powerful organizing principles and one of the most useful in information design for facilitating perceptual organisation of data. This principle can be used to signal a particular kind of graphic component in a consistent way and it can be used for emphasis of specific parts in a message. Similarity in a message will result in perception of that message.



Here we perceive two groups of dots, one with red dots, and one with blue dots. In each group the individual dots have the same shape and size, and they are approximately at the same distance from each other.

Spatial concentration principle

Proximity is not the only factor in predicting perceived groups. In accordance with the *spatial concentration principle (density principle*) we perceptually group regions of similar element density. Thus a visual element may belong to one group even if it is as close to another group.



We perceptually group regions of similar element density. The x-dot is closer to the a-group, but it may still be perceived as a part of the b-group.

Symmetry principle
According to *symmetry principle* we tend to group symmetrical components together. Our minds perceptually connect unconnected elements to form coherent shapes. Regions that are enclosed by symmetrical borders tend to be perceived as coherent figures.

Syncrony principle
The syncrony principle states that visual events that occur at the same time will tend to be perceived as going on together (Palmer, 1999, p. 259).

Affordance theories

According to Gibson (1977, 1979) we perceive the word both in terms of shapes and spatial relations of objects, as well as possibilities for *action*. Clues and stimuli in objects, as well as qualities of our environment, may potentially generate different actions in a direct and immediate way without any sensory processing. Thus perception can directly result in an action. The action is always within the physical capabilities of the *actor*. The actor can be a person, and also an animal. Gibson called this *affordance* in his *theory of affordances*. He coined the term affordances in order to describe how an animal perceives its environment. The *affordances* of the environment are what it *offers* to the animal.

Gibson's description involved the *interaction* between the animal and the environment. This is also how it has been used in education, emphasising active learning. Educational technologies offer learning activities, to be enacted by the learner in order to achieve learning goals. The term "affordances" appears in slightly different contexts in the education literature (e.g.

Collins, Neville & Bielaczye, 2000; Bower, 2008). In order to compare different media Koumi (2006, p. 65–66) identified fifteen attributes of media that can facilitate learning. Koumi used the term “characteristics” rather than the term “affordances.”

Norman (1988a, 1988b) borrowed the term *affordance* from cognitive psychology and he applied it to the *design* of physical as well as virtual environments and products. Norman made the concept dependent not only on the physical capabilities of an actor, but also dependent on the actor's own beliefs, experiences, goals, plans, and values. The designer of virtual environments and virtual products cares about *perceived affordances*, whether the user perceives that some action actually is possible or not. In product design, where one deals with real, physical objects, there can be both real and perceived affordances.

Some familiar everyday examples of affordance include our natural understanding that buttons are for pushing, cords and handles are for pulling, cylinders are for rolling, knobs are for turning, and switches are for flipping. All these designed objects invite us to act in the intended way. Here action and perception are linked together through real-world objects that provide action possibilities.

The concept affordance has rapidly spread within the fields of human–machine interaction, and interaction design. In graphical, screen-based interfaces, all that the designer has available is control over perceived affordances. In effect Norman's affordances “suggest” how the user may interact with an object.

Day and Lloyd (2007) argued that concepts derived from affordance theories are highly useful in understanding the role of online technologies in learning. They suggested that the value of this approach is maximised when the focus is moved away from the inherent properties of the technologies to the opportunities for learning provided by the total context in which the technologies are embedded.

Dalgarno and Lee (2010) explored the potential learning benefits of 3-D virtual learning environments. They identified a series of learning affordances of such environments. These affordances include the facilitation of tasks that lead to enhanced spatial knowledge representation, greater opportunities for experiential learning, increased motivation/engagement, improved contextualisation of learning and richer/more effective collaborative learning as compared to tasks made possible by traditional 2-D alternatives.

Waller (2011) discussed affordance qualities in documents and graphic design. In graphic design affordance may be checklists that afford the correct returning of key documents, contact information that affords the use of the right channels for customer queries, and print summaries that encourage previewing of key contents. In a document we tend to see significance in the way things are aligned, and in their relative prominence.

Today affordance theory has practical implications in a variety of fields such as: artificial intelligence, cognitive psychology, design, distributed cognition, environmental psychology, ergonomics, gaming design, graphic design, human-computer interaction, industrial design, information design, interaction design, instructional design, intelligent learning environments, learning technologies, perceptual psychology, robot technology, science, technology, user-centred design, visualization, and visual literacy.

Chemero (2003) discussed several theories of *animal affordances*. In his view animal affordances are relations between the abilities of animals and the features of their environments.

Perceptual qualities

Bertin (1983, 1989) provided a survey of “retinal variables” that are suggested to be perceived immediately and effortlessly “above” the picture plane and across the entire visual field. According to Bertin visual contrasts must be established by manipulating the perceptual qualities of size, value, hue, orientation, texture, shape, and position. These variables can all be manipulated to structure and enhance the experience of an image, a package, an environment, and a man-machine graphical user interface. Bertin’s taxonomy considers four styles of perception: 1) associative perception, 2) selective perception, 3) ordered perception, and 4) quantitative perception.

In *associative perception* the reader ignores variation on one visual dimension when reading a picture. A visual variable is associative when it does not influence our perception of other dimensions in the visual variables. A visual variable is dissociative when it severely influences our perception dimensions in the visual variables.

In *selective perception* the reader isolates instances of a specific category from other visual elements. This is the opposite to the principle of similarity. The task is to ignore everything but one specific value of one specific dimension.

M N Z K M N K Z E M K N M M K M Z E N M K
M **N** Z K M **N** K Z E M K **N** M M K M Z E **N** M K

The letter “N” is difficult to locate in the upper row. Here all characters have the same size, colour, and value. In the bottom row the perception of the bold letter “N” is a bit easier.

M N Z K M N K Z E M K N M M K M Z E N M K
M **N** Z K M **N** K Z E M K **N** M M K M Z E **N** M K

The letter “N” is difficult to locate in the upper row. Here all characters have the same size, colour, and value. In the bottom row the perception of the bold and red letter “N” is easier.

In *ordered perception* the reader must see the relative ordering of values along a perceptual dimension. Size, position and value are variables that are ordered. Objects can easily be arranged objectively from least to greatest. This is often used in diagrams.

In *quantitative perception* the reader must be able to determine the amount of difference between ordered visual elements. It is easy to estimate the difference in length between lines. However, it is hard to compare areas and even more difficult to compare volumes.

Preble and Preble (1989) noted that “everyday visual perception” is a continuous flow of complex interrelations. Visual elements have a conceptual relationship. Organizing a message can make perception much easier and learning more efficient. The message should have a moderate degree of complexity. However, complexity without order produces confusion, and order without complexity may produce boredom. Inappropriate use of graphical elements may direct learner attention away from essential learning cues, and depress subsequent achievement.

It can be concluded that our perception varies as a result of a number of factors, such as cultural and social status, the time and stage of our development, our mood, experience, memory, and other cognitive processes.

Perception of change

The least possible difference that can be detected between two similar stimuli is called *the just noticeable difference*, or *the differential threshold*.

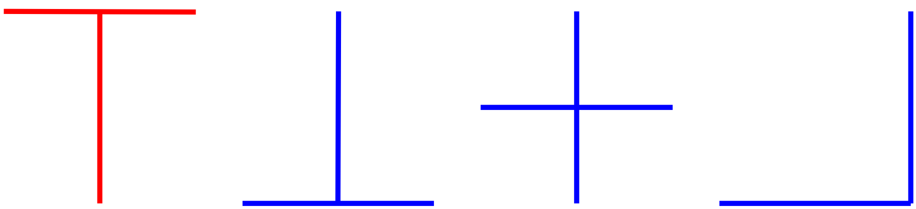
Ernst Heinrich Weber (1795 – 1878), a German professor of anatomy at Leipzig University, was one of the founders of experimental psychology (Wikipedia, 2012). When Weber studied our tactile senses and how they reacted to change he discovered that the just noticeable difference between two stimuli was an amount relative to the intensity of the first stimulus rather than an absolute amount. The stronger a stimulus is the stronger the increase needs to be.

Gustav Fechner (1801–1887), who was a professor of physics at Leipzig University, named Weber's results as "Weber's Law." Fechner further explored the just-noticeable difference and he argued for a logarithmic relation between physical and perceived magnitudes. This new law is known as "Fechner's Law" (1860). It is also known as the Weber–Fechner Law (Wikipedia, 2012): "In order that the intensity of a sensation may increase in arithmetical progression, the stimulus must increase in geometrical progression." This law formed the basis of "psychophysics." The "Weber–Fechner Law" has been useful within certain limits. In modern psychology the just noticeable difference (JND) is defined as "the minimum level of stimulation that a person can detect 50-percent of the time” (Cherry, 2012).

In modern marketing consumer tests can lead to early consumer acceptance and lower production costs (Nordmeyer, 2012). Manufacturers do threshold tests when they want to introduce new products in the market, or change ingredients in order to decrease production costs.

Perception of straight lines

Already around 1510 the Italian mathematician and Franciscan friar Fra Luca Bartolomeo de Pacioli (1445–1517), “father of accounting,” showed that horizontal lines seem shorter to us than vertical lines. He showed this 1510 in his *T-illusion* (Wikipedia, 2012).



These bars are equal, but the vertical bar seems longer (Sarcone and Waeber, 2011). We often have difficulty in interpreting simple relationships. Horizontal lines are often perceived as being shorter than equally long vertical lines. The red figure to the left is the T-illusion from 1510.

Pacioli wrote the famous book *De Divina Proportione* (*About the divine proportions*) on artistic and mathematical proportions, especially in architecture. The book has illustrations in woodcuts made after drawings by Leonardo da Vinci.

Horizontal lines are perceived as being shorter than equally long vertical lines (Thurstone & 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.

When relationships between variables are to be presented, comparisons of lengths in bar charts give the best results (Vinberg, 1981). When parts of a whole are to be presented, circle charts and pie charts may be used.

Perception of size

The perception of the size of a picture or a book page is very much influenced by contextual variables. There can be no large without small, and no small without large. In message design the most important part of a subject must be large and clear, take up a large proportion of the image area, and be perceivable as an entirety. Large individual visual elements in a picture attract the attention of the reader.

Lanners (1973, p. 66) noted that most people that are asked to draw a square with a side of about eight inches or larger freehand will produce something that is 1/30 to 1/40 wider than it should be. Many artists take this into consideration when they make illustrations to be published in books or magazines.

It is not easy to interpret differences between areas. Croxton and Stein (1932) tested the ability of 550 subjects to judge the relative size of bars, circles, squares and cubes. The main conclusions were: 1) Comparisons based on bar charts were more accurate than comparisons based on circles or squares. 2) Comparisons based on circles or squares were more accurate than comparisons based on cubes.

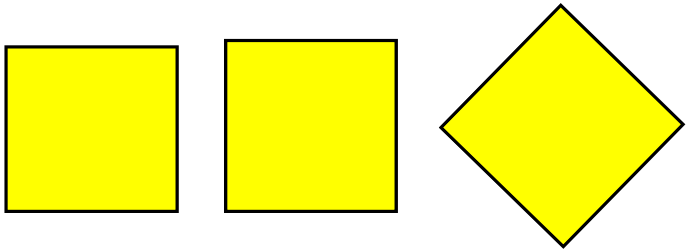
Pettersson and Carlsson (1985) asked 40 randomly selected subjects to assess the size of pairs of geometrical figures, randomly shown on a computer screen. The seven figure pairs consisted of 1) two vertical lines, 2) two horizontal lines, 3) one vertical and one horizontal line, 4) two circles, 5) two squares, 6) one square and one circle, 7) two circles with two pie-chart segments.

Each figure pair was shown in five variants. The size of the left figure, A, in each pair was constant during the experiment, whereas the size of the right figure, B, were selected at random in the interval from 50 to 150 percent of the size of A. For one-dimensional figures, the size was defined as the length of the line, and for two-dimensional figures, the size was defined as the area of the figure.

There was no time limit in this experiment. To input their assessments the subjects used an "answer tool." This was a vertical scale, going from zero to 200 percent.

With the exception of horizontal lines not being better than vertical lines, the results confirmed knowledge from print media (Pettersson, 1983b, p. 227). The mean errors amounted to about five percent for 1) vertical lines and 2) horizontal lines respectively. However, the error in comparisons between 3) vertical lines and horizontal lines was on the average ten percent. The errors in assessing 4) circles, 5) squares, and 7) pie-chart segments also were about ten percent. As expected, the greatest errors concerned comparisons between 6) circles and squares. Here the mean error was as high as twelve percent. These results, based on a total of 1400 assessments, clearly show that comparisons of areas cannot be recommended for general use, for example in the presentation of business graphics. Most likely comparisons of volumes are even worse.

A correct square seems to be too tall since we judge vertical lines as longer than horizontal lines. We judge a slightly shorter rectangle as a square. A correct square also seems to be too small if we compare it with a diamond with the same area (Thurstone & Carraher, 1966, p. 115).



A correct square (middle) seems to be too high since we judge vertical lines as longer than horizontal lines. Thus we judge a slightly shorter rectangle (left) as a square. We judge the square (middle) as smaller than an equally large tilted square (right).

According to McCleary (1983) it is known in cartography that in most contexts the differences in the perceived sizes of circles, diamonds, ellipses, squares, triangles, and a host of other two-dimensional symbols are underestimated.

Perception of depth

We have two eyes, and we naturally see in three dimensions rather than in one or two dimensions. The illusion of depth is created when our brains interpret the slightly different views from our two eyes. Convergence also provides important information about depth. When the eyes converge on a nearby object, the angle between them is greater than when the eyes converge on a distant object. Based on the angle the brain calculates the distances to the objects.

The stereoscope, and the Viewmaster, presents two slightly different two-dimensional photographs. When the eyes view the photographs simultaneously, the brain merges the two images to one combined three-dimensional image. The stereoscope was very popular during the later half of the last century as a source for education and entertainment. Stereocards viewed through stereoscopes were the main source of pictorial news.

Even though most pictures are presented on a two-dimensional plane or flat surface with a length and width, we expect them to have the illusion of depth, a third dimension. When we look at a still picture, or view a motion picture, time can be seen as a fourth dimension. People will employ their individual viewing behaviour, and see and interpret different messages in the same picture.

Depth is related to size, volume, weight, and mass. Spatial perception is not the perception of space as such but of the learned meaning of the relationship between different objects seen in space. The perception of depth is related to the relative size of known objects, to lighting conditions, to illumination and shadows, to judicious cropping, to linear perspective, to change of line weight, to texture gradients in the picture, to upward angular location of grounded objects, to interposition and overlap of picture elements, and to filled and empty space. Image elements conveying a sense of depth should be clear and easy to comprehend. Depth perception is also based on the different colours' of varying wavelengths. Warmer colours emphasize a foreground. Cooler colours emphasize a background. The spatial perspectives are important for our perception of depth. Compared with visual language factors like space, size, colour, lighting, and texture, the spatial perspectives are usually complex depth cues. A person's cultural heritage and social situation is always of vital importance for the perception of depth cues.

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. Painters and photographers often use several different types of perspectives to enhance the effect of depth in their pictures.

Line perspectives, aerial perspectives, colour perspectives, and overlapping perspectives may well be used at the same time to interact with each other and create lifelike pictures that are good representations of reality. However, for schematic pictures that are meant to show three-dimensionality, it is usually more appropriate to use only one of the different line perspectives at the same time.

Perception of colour

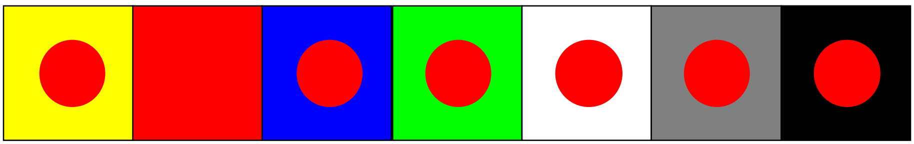
Hue, value, and saturation describe what we see when we look at pictures as well as the real world.

Hue

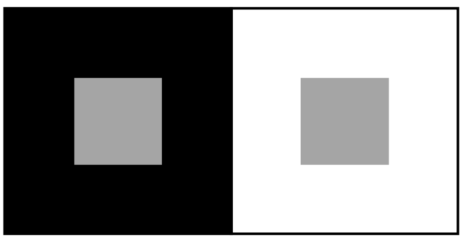
When we talk about the colour of an object we usually refer to the *hue* of that object. Most people are familiar with hue through our labelling of colours such as red, orange, yellow, green, blue, and violet. Different wavelengths of light reflected off an object are responsible for the hues. All of the colours in the rainbow are hues in the visible spectrum of light.

It is possible for us to see the difference between several millions of colour stimuli at simultaneous viewing (Evans, 1974). However, if not being seen simultaneously, the number we can identify is much smaller, maybe 10,000–20,000 hues (Hård and Sivik, 1981).

It has been assumed that our perception of colours is a two-sided phenomenon. The discrimination capability represents our possibility to differentiate a figure from its background. It is strongly influenced by and dependent on contextual variables such as lighting conditions and other surrounding colours. The colour identification capacity makes us capable of interpreting "the quality" of the object we perceive.



Our perception of one colour (here red), can change when it is placed on different background colours.



The eye discriminates differences between shades of gray in terms of relative brightness. Although the gray rectangles are identical they appear different.

Yellow, orange, and red hues are perceived as warm and active colours. 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 purity, and black often represents evil and darkness. However, it should be noted that certain colours have different meanings in different societies (Zimmermann and Perkin, 1982). The first three colours young children learn are red, blue, and yellow (Blood, 2003). So far no real explanation has been made to explain how the human eye perceives colour.

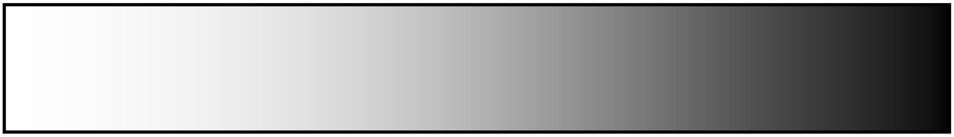
Gardner and Martinson (2005) found that the binding of naturally coloured objects is stronger than the binding of unnaturally coloured objects.

Subjects dislike the use of more than three or four text colours on the same page, screen, or slide (Pettersson, 1989). Colour coding is a good way to show that something is especially important and interesting. When text is shown on a visual display, there is no easily read colour combination.

A colour coding process may enable people to retain critical information and disregard redundant and irrelevant information. It is, however, known that extensively trained viewers can reliably recognize only about 50 colour codes. An effective and systematic colour code with a maximum of four to six colours in information material assists the viewer in categorising and organising stimuli into meaningful patterns.

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

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.)

Colour saturation influences our perception of shapes and objects. 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. Red is often seen as aggressive. In information graphics and statistical presentations, the most important elements should have the brightest colours, with the best contrasts to the background.

In multi-colour map design, the contrast effect of different hues provides the most dominating visual clue in differentiating different symbols. The most legible combinations of print colours is black or dark brown text on a light yellow background. Other combinations may attract more attention but are less legible and, thus, require bigger letters.

For discriminating of colours on maps, Keates (1982) found that three factors are important. In the first place, for hues that have a high lightness value (such as yellow) only a few differences in saturation are apparent. Conversely, for a dark blue or red, a larger number of perceptible differences can be made between maximum saturation and a neutral grey of the same value. Second, the perceptible differences in value (lightness) and chroma (saturation) are not symmetrical for different hues. In the third place, the ability to discriminate between different saturations of the same hue is strongly affected by the area of the image and by spatial separation. Fine discriminations in saturation and lightness are only possible if there are no other colour distractions. If other colour elements, such as lines crossing the areas, are introduced, then the ability to distinguish slight differences in saturation or lightness is decreased.

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 and shape

Many researchers have studied the relationship between colour and shape as stimuli. Otto and Askov (1968) found that the importance of these stimuli is related to the respective subject's level of development. 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. Modreski and Gross (1972) found that four-year-olds were better at pairing objects by shape than by colour.

Ward and Naus (1973) studied pre-school children and found that they were also better at identifying objects by their shape than by their colour. MacBeth (1974) found that children from three to eight emphatically tended to sort coloured paper by shape rather than by colour, so shape is often more important to children than colour. According to Keates (1982) the term *shape* is reserved for the spatial arrangement of geographical features. The apparently equivalent term *form* can only be applied directly to point or line symbols on maps. Form is an element in identification, whereas shape leads to recognition.

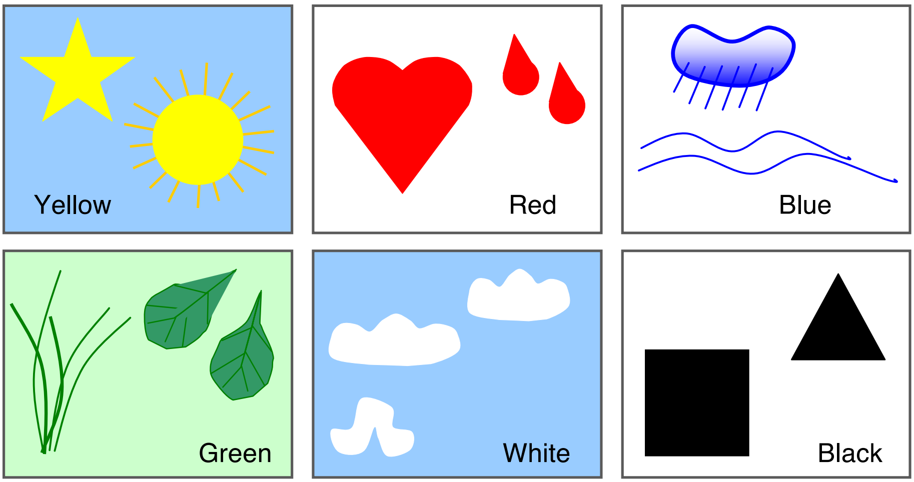
Itten (1971) maintained that shapes, like colours, have their own sensual, expressive value. The expressive qualities of shape and form must provide mutual support. All shapes characterized by horizontal and vertical lines belong to the "square shape category" i.e., even the cross, rectangle, and similar shapes. The square is equivalent to the colour red. The weight and opaqueness of red is related to the static, heavy shape of the square.

The triangle's pointed vertices suggest belligerence and aggression. All diagonal shapes in nature, such as the rhombus, parallel trapezoid, zigzag lines, and similar shapes, are counted as triangles. The triangle is the symbol of thought. Its chromatic equivalent is yellow. Shapes circular in nature, such as the ellipse, oval, waves, parabola, and similar shapes, belong to the same category as circles. The chromatic equivalent of the unceasingly restless circle is blue.

In his comprehensive "symbols dictionary," Symbol Sourcebook, Dreyfuss (1972) described a large number of meanings for different, basic geometric shapes. These meanings varied considerably from one field to another. As far as the correlation between colour and shape is concerned, Dreyfuss pointed out that the following tradition prevails: yellow–triangle, orange–rectangle, red–square, purple–ellipse, blue–circle, green–regular hexagon, brown–rhombus, black–parallel trapezoid, white–semicircle, grey–hourglass, silver–bi-concave, and gold–bi-convex. Accordingly, one might well ask if there is any correlation between traditional perceptions and "natural" or spontaneous views of matches between shape and colour. In order to shed some light on this matter, we performed two empirical studies, one devoted to the colour-shape relationship and the other devoted to the shape-colour relationship.

One special case of shape recognition is face recognition. Infants are born with a preference for gazing at faces rather than at other objects. At just thirty minutes of age, they will track a moving face farther than other moving patterns of comparable contrast, complexity, and so on. Farah (1995) showed that face recognition and common object recognition depend on different systems that are anatomically separate, functionally independent, and differ according to the degree of part decomposition used in representing shape.

Colour-shape experiment
A total of 118 upper-level comprehensive school students and 12 adults took part in a colour-shape experiment. They were given an A4-sized sheet of paper on which the names of six colours, yellow, red, blue, green, white, and black, were printed in a random sequence. The subjects were asked to "draw the shape you feel best matches the respective name of a colour." They had 15 minutes to complete this assignment.



Here are examples of the most typical figures that the subjects made associations to when they were given a colour name as stimulus.

Subjects also supplied information on their age and sex. They produced a total of 780 visual statements on the correlation between colour and shape. The results clearly showed that there was no natural, spontaneous, and unambiguous correlation between colour and shape. The colour names used all gave rise to many different geometric shapes. In no instance did an anticipated, traditional shape predominate over other shapes.

In three instances, the anticipated shape was not drawn at all. In the other three instances, the anticipated shape was only drawn in 2–3% of the visual statements.

The study disclosed a considerable spread in the way subjects develop associations with different natural phenomena, different objects, and different geometric figures. One or more subjects predominated for each colour. Subjects related yellow primarily to the sun and other heavenly bodies, red to love and blood, blue to water and clouds, green to various kinds of plants, and white to clouds or snow and even, like black, to various geometric figures. Geometric figures delineated by straight lines were more common for white and black than was the case for "soft" figures. Rectangles, squares, and triangles were particularly common. The study also showed that there is no real difference between boys and girls, regarding associations between colour and shape. Intra-group variations were greater than inter-group variations.

One interesting finding was that subject's perceived shape as a coloured area, only infrequently delineated by a line. Thus, yellow is a yellow area, red is a red area, blue is a blue area, green is a green area, and black is a black area. White is a white area delineated by a thin line (on white paper). Several subjects probably did not regard white as a colour. Colour was divorced from shape for subjects in the adult group. Thin lines delineated all colours in this group (pencil, ball point, India ink).

Shape-colour experiment

A total of 157 upper-level comprehensive school students (not the same as those who participated in the colour-shape experiment) were each given an A4-sized sheet of paper on which six shapes, i.e., a square, star, "jigsaw puzzle piece," circle, triangle, and rectangle, were printed. Their task was: "Colour the shapes on this page. Select the colours you feel are best suited to the respective shape." They had 15 minutes to complete this assignment. Subjects also supplied information on their age and sex. They produced a total of 942 visual statements on the correlation between shape and colour.

The results clearly showed that there was no natural, spontaneous, and unambiguous correlation between shape and colour. We sorted the visual statements on each page into the following colour categories: yellow, orange, red, purple, blue, greenish blue, green, yellowish green, brown, black, white, grey, and "multiple simultaneous colours." No form had less than 11 of the 13 colour categories. The most common colours were as follows:

1. *Triangle:* purple (14%), orange, blue, and green (each 13%).
2. *Star:* yellow (34%), orange (22%), and red: (12%);
3. *Square:* blue (32%), red (15%), and purple (14%);
4. *Rectangle:* green (16%), purple, blue, and brown (each 13%);
5. *Circle:* red (22%), purple and blue (both 15%);
6. *"Jigsaw puzzle piece":* red (22%), purple (20%), and green (16%).

In total, the most popular colours were blue (16%), red (15%), and purple (14%), followed by green (12%), yellow (11%), and orange (10%). The colours used least were brown (6%), black, and greenish blue (4% each), "multiple simultaneous colours" and grey (both 3%), yellowish green (2%), and white (0%). This colour scale is in rather close agreement with previous studies of colour preferences.

Eysenck (1941) tabulated the results of experiments on colour preferences. The results of evaluations made by more than

21,000 subjects produced the following ranking: 1) blue, 2) red, 3) green, 4) purple, 5) orange, and 6) yellow.

Differences in colour perception

Man's colour perception and discrimination vary in varying lighting conditions. However, certain differences in the use of colour by different cultures may have an ecological basis.

The earth is round and rotates on its own axis in such a way that light rays from the sun are almost perpendicular when they strike the surface of the earth in areas near the equator. To the north and south, the angle of incidence changes so that each ray of light illuminates an increasingly larger area. The light's angle of incidence has a major influence on climate and even on reflectance and illumination. Normal variations in terrestrial surface illumination – depending on the time of day, location, and weather – are sufficient to cause an object to display objective variations in colour.

On the basis of learning and experience, Western adults know, for example, that a house standing partly in shade and partly in direct sunlight probably has the same colour on all its exterior walls since this is common practice in the Western world. However, the perception of shape, size, and colour constancy common to Western societies is not necessarily valid in all other societies. In fact, considerable evidence suggests that perception of these factors differ in equatorial regions.

The ancestors of man, the hominids, evolved in Africa. According to Kurtén (1971), the hominids on the one hand, and the apes on the other, branched off on separate evolutionary pathways more than 35 million years ago. Vast migrations took place during the Miocene epoch, from 25 to 10 million years ago, and the Pliocene epoch, from 10 to 3 million years ago. The antropoid apes, and subsequently lower apes and hominids, migrated from Africa and settled in Europe and Asia. Some of the hominids remained in Africa. The various hominids evolved in partially different ways. All were forced to adapt to the prevailing environment and its demands. Only those capable of adapting survived. As Kurtén (1971) put it: "When climate or other environmental influences are extreme, man's physical characteristics are still governed by natural selection, even though we now do our best to circumvent these influences by means of air conditioning, double-glazed windows, etc." Kurtén also remarked:

> So in a hot climate, it is still advantageous to have a lanky build, dark skin, wooly hair and effective sweat glands. Being short may also be an advantage since the ratio between the body's area and volume increases. And if you need body fat as an energy depot, it is better to have that fat concentrated at a limited number of sites so it does not hinder heat exchange.
>
> In a cold climate, on the other hand, it is better to be light-skinned so you can make the most of what sunlight there is. Being large or at least stocky with a short neck is also an advantage. Body fat should be evenly distributed as insulation against the cold, especially chilling of the face, a part of the body otherwise difficult to protect.

Equatorial people, for example, those living in central Africa, are ecologically adapted to life in a climate characterized by bright sunlight, extremely bright days, and dark nights. In bright light all colours and contrasts decline in intensity. It then becomes more difficult to distinguish one colour from another. This also is the case on dark nights. The landscape and environment are then almost monochromatic black and white. Bright sun high in the sky casts dark shadows.

Many animals have adapted to these conditions by acquiring protective colouring. For people evolving in such an environment, highly developed black/white vision (i.e., a large number of efficient rods in their retinas) should be advantageous to survival. This would enhance their ability to see well in darkness and shadow, to avoid danger and enemies, to discover game, and so on. Good black/white vision is also indispensible in bright light. Equatorial Africans do indeed have exceptional vision. For example they are often able to see immobile animals at great distances, long before non-African, particularly European, members of a safari party detect these animals.

As latitude increases in the colder climates to the north and south, light from the sun strikes the earth at an increasingly smaller angle of incidence. Large parts of the day consist of various phases of dawn or dusk. In the summer half of the year, it never gets really dark, and in the far north it stays light throughout the night. There is an almost endless array of colour nuances in environments such as these. Here, highly developed colour vision is ecologically important for the same reason as those previously cited for well-developed black/white vision near the equator. Well-developed colour vision offers greater opportunities for survival than does poor colour vision where the environment is rich in colours. It seems likely that the peoples who settled to the far north and far south gradually developed more refined colour vision and a considerable ability to perceive colours, perhaps at the expense of black/white vision.

It is possible to use various aspects of vision in different ways at different times. The sensitivity range of the rods and cones varies considerably in various lighting conditions. Smith

(1969) claims "a normal eye is capable of increasing its light sensitivity 75,000 times during one hour of vision in darkness." He also maintains "all people are colour-blind in weak light. In the evening, red is the first colour whose discrimination becomes impossible, followed by other colours in the same sequence as the spectrum. Blue is the first detectable colour in the morning".

According to eight different papers cited by Bornstein (1973), several parts of the eye, such as the sclera, cornea, iris, lens, and retina have been shown to vary in degree in regard to pigmentation. Wald (1945) isolated retinal macular pigmentation and identified it as xanthophyll, a carotenoid that absorbes heavily in the blue part of the spectrum. Even direct ophthalmologic investigations have shown that yellow pigmentation in the eye covaries positively with skin pigmentation (Silvar and Pollack, 1967). The yellow pigmentation increases as the amount of exposure to ultraviolet radiation increases. People living in higher altitudes or nearer the equator are likely to have more yellow intraocular pigmentation. Bornstein (1973) also reviewed six different studies showing that people having more ocular pigmentation display reduced sensitivity at the short wavelength side, particularly in the blue area. From these different findings Bornstein concluded that physiological differences, that is, "yellow intraocular filters," may selectively reduce the amount of short-wavelength visible radiation reaching the photoreceptive cells in the retina, resulting in:

> 1) a depression in the phototopic luminosity function at the short wavelength end and 2) a reduction in the perception of "blueness." The latter effect may be likened to a graying

> or darkening of the short wavelength end of the spectrum resembling blue weakness or, in extreme cases, tritanopia.

According to Bornstein, this explains the cross-cultural differences in the use of colour naming. As discussed later, however, this does not appear to be a sufficient explanation in itself. Bornstein also cited several studies that give evidence that "yellow intraocular filters," also have the effect of increasing visual acuity. Since eye pigmentation is correlated with both visual acuity and skin pigmentation, it follows that dark-skinned people would generally have better visual acuity than light-skinned people. Learning, though, also plays a major role in perception. It is conceivable, for example, that the non-African safari members mentioned earlier could learn to detect distant, immobile animals.

Colour preferences

Various studies, including my own (Pettersson, 1981), indicate a general tendency for people to prefer colour pictures to black-and-white renditions of the same subject. But within this general tendency, myriad variations in colour preferences have been identified; many of these variations seem to be correlated with cultural factors.

Eysenck (1959) tabulated the ratings of various colours by 21,000 American subjects. There was no difference in the average rankings according to the assessments of the 12,175 whites and 8,885 blacks. Both groups ranked the colours as follows: blue, white, green, violet, orange, and yellow. On the average, though, the black subjects liked blue and violet better than the white subjects. White subjects tended to like white, green, orange, and yellow better than did black subjects.

Stewig (1974) studied the preferences of 1,000 American children for various components in a pictorial presentation. Four independent variables – school grade level, sex, socioeconomic background, and race – and five dependent variables – colour, shape, size, richness of detail, and three-dimensionality – were examined. The results of the study disclosed no significant overall differences, but white subjects selected realistic colours significantly more often than did black subjects.

In a comparison of the ratings by Swedes and Greeks of colours according to 26 different colour scales, Sivik (1970) found no general differences. However, Swedes rated bright colours as more "clashing" than the Greeks. By the same token, Swedes regarded the weak colours as more "discrete".

A study of clothing, textiles, religious symbols, tools, weapons, works of art, and other objects on display at such museums as the Museum of Natural History (New York), the British Museum (London), the Louvre (Paris), the National Museum of Natural History (Washington D.C.), and the Royal Ontario Museum (Toronto) has been both useful and interesting. I have studied thousands of such articles and found that articles from older cultures in Europe, North America, Greenland, China, Japan, and the Soviet Union were frequently made in many different colours with a wide range of hues. In contrast, objects from cultures in Africa, Central America, South America, and Indonesia featured only a few bright colours; white, black, red, yellow, green, and blue were common colours for these objects.

These observations suggest that dark-skinned people who have not been too greatly influenced by European culture tend, for example, to prefer very brightly coloured apparel. Such a preference might be explained by physiological differences in the eye that lead to a need for greater chromatic stimulation to facilitate perception of colours. Indeed, patterns in locally woven cloth and paintings are often marked by clear, sharp colours. In a book on Gambia, Berglund (1975) noted that:

> The dazzling nature of the woman's clothing is virtually unsurpassed in Africa, even if things have been toned down since the advent of tourism. Many girls have begun wearing European clothing. But the dress of the frequently beautiful Wolof women can still be seen in a cascade of brilliant emerald green, indigo, ruby and gold, the proud heads of the women topped by high multi-coloured turbans.

A first impression gained by many foreigners visiting Japan is that "all" Japanese men dress in identical, dark-blue suits. However, a closer look would reveal that many of the suits differ considerably. They differ by means of slight variations in colour and by variations and details in patterns. The Japanese pride themselves on making subtle combinations of colours and textures. This art form is referred to as "Shibui." Japanese art is not as wide-ranging as European art, but it attains greater perfection within its chosen framework. Its limitations are attributable to the fact that Japanese artists historically have had fewer methods and opportunities for expression than their Western counterparts.

According to Hillier (1975), Japanese art uses lines and nuances to arouse emotions. This can be equated with the way a word or turn of phrase is employed to evoke emotions in Western poetry. In the 17th century, Japanese artists and printers would sometimes use more than 10 different blocks in making one of their exquisite woodcuts. "They were able to attain an amazingly broad scale of colours when they printed block impressions one on top of another".

Hultén (1978) has studied African art and found that organic aspects predominate, with man and concepts dealing with man as central themes. Comments Hultén:

> On a number of occasions and in different places, paintings have been made identical to European abstract art. But by artists unaware of this art. Most of the image forms dominating Western art in this century can be found in folk art. Abstract shapes and symbols and symbolic concepts are all much more common in folk art than realistic depictions. The African is closer to sources than European artists.

Hultén further noted: "An African ceremony is an incredibly colourful experience. Colours are employed to symbolize the spirits of the dead, a totemic animal, menstruation, the sun, etc. Unequivocal messages – communication by means of colour."

The exhibition "Modern Art in Africa" on display at the Liljevalchs Gallery in Stockholm January 18 to February 24, 1980, and previously shown in Berlin and Bremen, with about 400 works from 16 countries, provided a good overview of African art of the past 40 years. Characteristic of all the works were extremely bright and distinct colours using a striking colour scale in which yellow, red, and blue were common, in addition to black and white. But to Swedish eyes, the pictures frequently looked flat, lacking a sense of depth.

The practical educational consequences of such cross-cultural differences in colour preference were highlighted by a series of interviews I conducted with representatives of African publishing companies in 1980. The publishers, from Ghana, Nigeria, and Ivory Coast, lamented that European textbooks and children's books were not suitable in their countries although educators in those countries had been using such books for many years out of economic necessity. In lengthy discussions of the pictorial elements of European textbooks, the African book people typically made such comments as:

– European books are so colourless.
– Our children prefer pictures with bright, lively colours.
– We prefer drawings to colour photographs. Photographs have too little colour. The colours are almost invisible. Drawings are better. Then we can have the colours we want.
–We like bright colours in both pictures and clothing, for example. In Scandinavia, you always use such pale colours. Your colours are so indistinct.

It seems that 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.

Colour naming

Berlin and Kay (1969) studied the way colours are depicted in 98 different languages. Their results provided strong support for the existence of about 11 focal colours, that is, colours readily perceived by all ethnic groups. The focal colours are believed to be red, yellow, green, brown, blue, orange, pink, purple, black, white, and gray.

Heider (1972) found that Dani, a language of New Guinea, has only two expressions for colours, roughly equivalent to “dark” and “light.” Mangan (1978) noted a similar situation in many African languages. Kokuhirwa (1977) found that the Wanyashimo language of Tanzania had words for white, red, green, and dark, but no word for blue. Speakers of that language use “light” or “white” for pink; dark blue is always “dark” or “light”.

Jacobson-Widding (1979) reported that the traditional cultures in the whole of central, eastern, and southern Africa have names only for white, black, and red. These colours are employed in ritual art and magic, as well as in secular ceremonies and metaphores.

Some cultures have names for four, five, or six colours. When a culture has a name for a fourth colour (in addition to white, black, and red), it tends to be yellow; the fifth tends to be green, the sixth, blue, and the seventh, brown. It is noteworthy that this sequence of preferences corresponds closely to the series of colours in the visible light spectrum, taken in descending order of wavelength.

If only a limited number of colours are used in ritualistic art in all these cultures, then only these colours are assigned names of their own, that is, “basic colour designations,” in the respective language. Languages with more than eight colour designations are found, for instance, in Europe, India, China, and Greenland. Jacobson-Widding (1980) reported that hunting societies in arctic areas had a very rich and extensive colour language, both in terms of terminology and in the use of colours in daily life. “The Eskimoes have at least a dozen basic terms for different colours in addition to an apparently infinite number of secondary colour terms".

In their discussion of American Indian languages, Englund and Svenström (1974) pointed out that:

> It would be incorrect to believe that the Indian languages were primitive and poorly developed. They were quite the opposite and highly specialized for the environments and societies in which they were spoken. The Comanche Indians have no less than seventeen different designations for the colours of a horse, equivalent to "bay," "roan," "paint," etc. in English.

The Comanches also have a large number of designations in their language for colours other than those describing horses.

This inexorable consistency in the use of colours and colour terms in different cultures has recently begun to be explored by cultural anthropologists. For example, Bornstein (1973) discussed in great detail the cultural differences in colour naming and illusion susceptibility. He analyzed approximately 200 ethnographies or language sources (including those of Berlin and Kay) and derived a number of general conclusions, including: people all over the world distinguish semantically between black and white (or light and dark); some cultures subsume red and yellow under the same name; and many languages fail to distinguish between green and blue, or between blue and black, or among green, blue, and black.

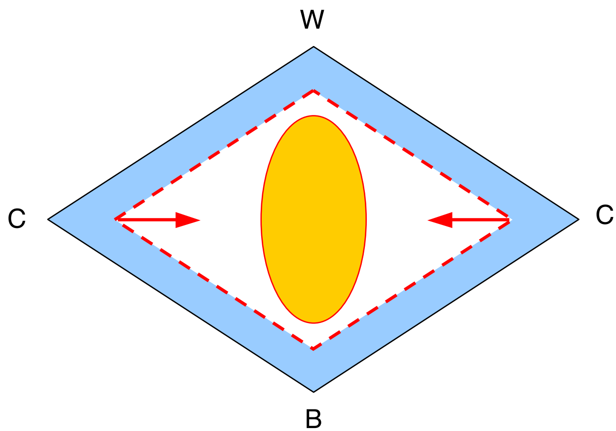
The absence of words for colours is not in itself sufficient evidence to prove the inability of a people to distinguish different colours. It is, however, an indication that colours other than those assigned names are not regarded as linguistically important. Given the interaction between language and perception, one could hypothesize that the greater the number of linguistic concepts related to colour in a language, the greater the subtlety of colour perception in that culture.

In summary, it is clear that there are major differences in the perception, naming, and use of colours in different cultures. To date no satisfactory theory has been found to explain causal relationships. Some evidence suggests that these differences may be related to latitude and lighting conditions, but convincing direct evidence is still lacking. I believe that these differences in colour use may originally have been based on each group's ability to see or experience various colours, with this in turn based on illumination and reflectance conditions at the respective latitudes and in the respective environments.

A suggested model for sensitivity of vision

In the Natural Colour System, developed by the Scandinavian Colour Institute, different colours have their specific positions in a double cone according to whiteness, blackness, colour, and chromatic amount of colour. I believe it is also possible to describe, in a similar three-dimensional figure, a model of the sensitivity range of human vision during different lighting conditions. When the light is right, it will be easy to perceive different colour tones. However, when the light becomes lighter or darker, it will be harder to see and to perceive colour tones. The range of sensitivity shrinks. The size and shape of the sensitivity range will, of course, be different for different cross-sections of the double cone because different cuts will hit different colours.

This model should be regarded only as a declaration of a principle. The causal factor being proposed here is the presence of "yellow intraocular filters" in the eyes of dark-skinned people. Such a physiological feature makes sense from an ecological point of view. The filters act, in effect, as built-in sunglasses, protecting the retinas from too much light on sunny days. The filters happen to make it easier for people having them to distinguish between different colours, except blue. It is quite possible that blue colours are less important to humans than other colours; thus it would be sufficient in an actual life situation to perceive blue tones as shades of gray. In addition, the increased visual acuity is a great asset, especially during bad lighting conditions.



Model to depict the sensitivity range of human vision during different lighting conditions. During ideal conditions (dotted red line) we will perceive many hues. The sensitivity range shrinks when the light becomes lighter or darker. W=whiteness, B=blackness, C= chromatic amount of colour.

In theory, the presence of “yellow intraocular filters” would mean that the size and shape of the sensitivity range, representing human visual perception, would be somewhat different among groups of people whose ancestors originated at different latitudes.

Influence of context

The context of an image may influence our perception of the image. Vernon (1962) noted that the perceived size of an object is relative to the size of other objects. The size of an unfamiliar object is perceived as relative to the size of familiar objects (Pick and Ryan, 1971).

Grey levels

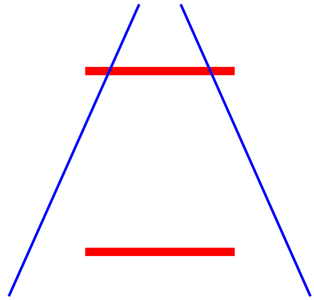
Open and light forms are perceived as being larger than closed and darker forms of the same shape in the same size (Thurstone and Carraher, 1966, p.118). According to Lanners (1973, p. 59) "bright figures seem larger than dim ones."

These rectangles all have the same size but we may easily perceive them as different in sizes because of the different grey levels.

The Ponzo illusion

Mario Ponzo (1882–1960) was an Italian psychologist. He suggested that the human mind judges the size of an object based on its background. In 1911 Ponzo draw two identical horizontal lines across a pair of converging lines, similar to railway tracks receding into the distance. The upper line looks longer because we interpret the converging sides according to linear perspective. This optical illusion is known as the *Ponzo illusion* (Sarcone & Waeber, 2011).

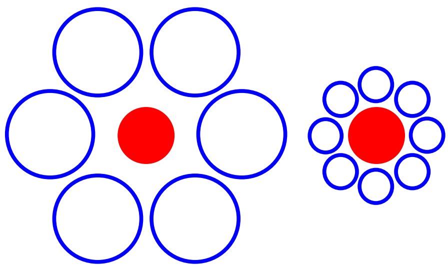
The two horizontal and red lines have the same length, but upper line circle appears to be longer.



The Ebbinghaus illusion

The German psychologist Hermann Ebbinghaus (1850 —1909) pioneered the experimental study of memory. He discovered an optical illusion (1901), which is known as the Ebbinghaus illusion, or the Titchener circles (Roberts et al., 2005). Two circles of identical size are placed near to each other. Large circles surround one circle, while small circles surround the other. The first central circle appears smaller than the second central circle.

The two red circles have the same size, but the left circle appears to be smaller than the right circle.



Constancy

We interpret the data from our sense organs with a bias towards constancy. Usually, there is a *constancy* of brightness, colour, contrast, shape and size in the perception of known objects. This is regardless of distance, angle, and illumination. 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.

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

Colour constancy is our tendency to judge the colour of an object as the same despite changes in distance, viewing angle, and illumination.

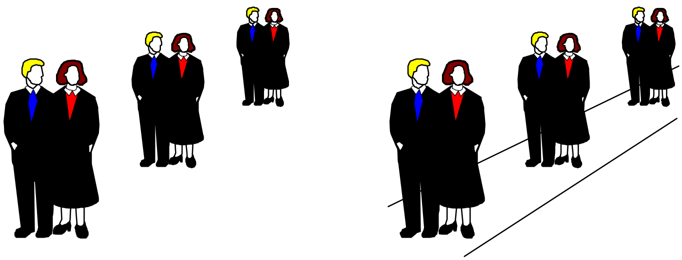
Colour constancy is our tendency to judge colours as the same despite changes in distance, viewing angle, and illumination.

Contrast constancy is our tendency to judge contrasts as the same despite changes in distance, viewing angle, and illumination.

Loudness constancy is our tendency to judge the loudness of a sound as constant, even though changes in distance make the sound seem louder or softer.

Shape constancy is our tendency to judge shapes as the same despite changes in distance, viewing angle, and illumination. This is one of the reasons that the circle, the oval, the triangle, the square, the rectangle, and the rhombus often are used in symbols and icons. Perception of a text is always relative. Therefore people will perceive a text in different ways. However, there is a large degree of perceptual constancy. We can view a text and read it from various distances and various angles and still get the same understanding of the text content.

Size constancy is our tendency to judge the size of an object as the same despite changes in distance, viewing angle, and illumination.



The six persons (to the left) can be considered as different in size. The addition of the two lines makes it easier to perceive the persons as people seen on different distances. The perception of distance is related to the perceived size, and the perception of size is reciprocally related to the perceived distance.

Picture perception experiments

In several experiments subjects have been given different assignments. Thus subjects have been asked to name image contents, to describe image contents, to index image contents, to write captions, to assess image contents, to create images, to complete a story, to illustrate a story, to produce informative materials, to produce information graphics and to describe picture context. Results from these experiments, based on more than 77,000 verbal and visual statements from 2,500 subjects, confirm the theory of a dual stage perception. It is suggested that different assignments cause perception and image interpretation on different cognitive levels.

Object recognition

According to Dake (1999) human perception has a tendency for immediate object recognition. The left hemisphere of the brain exercises inhibitory control over the right hemisphere and substitutes the recognition and naming of visible forms in the visual field. The mechanism for this quick initial classification and naming is the perception of primitive geometric components called Geons (Biederman, 1987). The 36 identified Geons are analogous to the 55 phonemes, that are the components of all spoken language. This powerful mental ability for recognition of patterns and objects limits immediate perception to the most obvious meanings in pictures.

To name image contents

When Snodgrass and Vanderwart (1980) asked 219 subjects to name 260 simple line drawings with concrete image contents such as “a doll,” “a finger,” and “a trumpet,” they found that 80 percent of the pictures were given the anticipated answers. In one study (Pettersson, 1986a), 80 adult subjects were shown five illustrations. These concrete image subjects showed “two house martins in flight,” “a young tadpole,” “a squirrel with a nut between its front paws,” “a gnawed spruce cone,” and “a bird nesting box.”

In the following pages, these drawings will be referred to as “the five illustrations.” Subjects were asked to describe the content of each image. All subjects answered with very concrete and directly content-related, descriptive words. A total of 400 words were used. Usually two or three different words were used for each picture. The mean value was 2.8. The frequency for the most common word was high. The mean value was 60.5.

One of the five illustrations ("two house martins in flight") had been used in a previous study of eye-movements (Pettersson, 1983d). Within one or two seconds ("immediately"), subjects recognized the concrete image content ("two birds" or "two flying birds") in the picture. This had also been true of other eye-movement experiments, for example, Potter and Levy (1969). These results all indicate that there is an image interpretation mode in which the "whole" and "immediate" concrete contents of an image are perceived.

Intended and perceived meaning of icons

In 1988, a study was conducted under my leadership by CLEA at Stockholm University of the way subjects perceived the meaning of icons, i.e., symbols employed in computer programs (Scüsseleder and Troedsson). The study comprised empirical experiments with two groups, each comprising 48 subjects. The task of subjects in one group was to supply oral descriptions of 38 icons in commercially available computer programs for the Macintosh computer. Subjects in the other group listened to program manual definitions read aloud to them and were then asked to point to the respective icon. In both instances, the experiments were performed in random sequence. So the statistical material encompassed 3,648 statements.

The results showed that there was a very considerable difference between the interpretation of icons by subjects and the intended meanings. Not a single icon was correctly interpreted by all the subjects in either of the two sets of experiments. Only 10.5% (4) of the icons were correctly interpreted by at least 75% of the subjects. Only 23.7% (9) of the icons were interpreted correctly by at least 50% of the subjects. As expected, results were better when the task was to relate icons to their verbal definitions. Here, 47.4% (18) of the icons were correctly interpreted by at least 75% of the subjects 63.2% (24) were correctly interpreted by at least 50% of the subjects. So the range of association options was greatly restricted when verbal descriptions were available.

Griffin and Gibbs (1992) asked U.S. and Jamaican subjects to identify 48 symbols. It was expected that subjects would easily recognize and identify the symbols. This was, however, not the case. A "difficulty index" of .45 indicates that U.S. subjects recognized less than half of the symbols correctly. For the Jamaican subjects, it was even lower, .25.

To describe image contents

Subjects have been asked to make descriptions of the contents of images (Pettersson, 1985, 1986a). In one case, 80 subjects (other than those mentioned above) made brief descriptions of ten pictures, all intended to convey abstract image contents. Only some (12.5%) of these 800 descriptions contained the anticipated "key words." Each picture was described with several different descriptive words. The 80 subjects utilized 1,406 words that can be regarded as "key words." For each picture the number of different key words ranged from 31 to 51 with a mean value of 37.6. The four most common key words for each picture accounted for half of all the key word designations (51%). Most of the designations were only mentioned once or a couple of times. In subsequent experiments, 80 subjects have made detailed descriptions of "the five illustrations." These descriptions comprised 15 to 300 words. Here too, a large variety of descriptive words were used. Mean values were between 59 and 119 words.

To index image contents

Copies of “the five illustrations” were also subsequently given to 125 other subjects. Subjects were given the following task: “These five pictures are to be filed in a picture archive. Write one or more index words for each picture.” In this case, subjects answered with 40 to 51 different index words for each picture with a mean value of 43.6. A total of 1,034 words were used. The words expressed in the first study were always the most common in this test. On the average they account for some 48 percent of all the words used as index words for each picture. The three most common index designations for each picture accounted for half of the index designations (52.5%). Most of the designations were only mentioned once (51.8%) or twice (17.4%). Concrete, descriptive designations dominated. Thus this study confirms the findings from the previous study with brief descriptions.

The suggested index words can be organized into various hierarchic structures with abstract and concrete words, as well as synonyms and near synonyms. Several of the words that were used clearly show that the images have been carefully studied. These results all indicate that there is an image interpretation mode in which details and the abstract contents in an image are perceived.

To write captions

Ten pictures were shown subsequently to some 80 students taking a course in visual communication. The students were asked to compose captions which were 1) positive and reinforced image contents, 2) negative and weakened image contents, and 3) neutral and neither reinforced nor weakened image contents. Subsequent reviews of the captions (approximately 2,100) and also discussions in class showed that picture captions clearly have an ability to affect our perception of the image content. Actually the caption has a very great impact on our image perception. It might be said that to a large degree readers see what they are told to see in an image. This is also shown in eye-movement studies (Pettersson, 1986b).

To rank and rate images

Experiments with rankings and ratings of pictures (Pettersson, 1983c) showed that picture readability is positively correlated with both aesthetic ratings and assessed usefulness in teaching.

In order to study children's preferences regarding image shapes, the author had a realistic black-and-white drawing made of house martins in flight against a grey background. The image was reproduced in eight different croppings and in sufficient quantities to permit comparison of all the image shapes in pairs. Each pair was mounted on a sheet of paper inserted in a binder. The visuals differed only in the shape of the image background. In one version there was no tint block i.e., the drawing was a "free shape" on white paper. The other shapes were oval, round, square, video format, horizontal rectangle, vertical rectangle, and triangle. The 28 possible image pairs were mounted and numbered at random. A total of 30 girls and 35 boys from 10 to 12 years of age then told an interviewer at a private session which image in each pair they liked best (a total of 1,764 possible choices). The results were analyzed with the aid of a binomial normal distribution test and disclosed a significant preference for the "soft" image shapes. On the whole, the following rankings were obtained: 1) oval 2) and 3) video format and "free" shape 4) and 5) round and square 6) low rectangle and 7) and 8) high rectangle and triangle.

On another occasion, 36 girls and 39 boys aged 8 to 12 ranked five pictures placed at random on a table. The picture was a realistic drawing in colour depicting “oyster catchers in a lake-shore meadow.” Each picture had a different cropping i.e., oval, round, video format, rectangular, or square, with the subject at the centre. The same procedure was used in this experiment as with the pictures of house martins. In both studies, all the pictures had the same image area (69 cm^2). Statistical analysis (homogeneity test, utilizing the hypothesis that rankings of different image shapes are equally distributed) of the children’s rankings of image shapes showed that they displayed a significant preference for the “soft” image shapes.

Both experiments clearly showed that children, on these occasions and with the subjects chosen, definitely preferred “soft” images to images with rectilinear framing. The results suggest that the use of more “soft” pictures in our textbooks might be justified. The latter experiment with children was repeated in London in the spring of 1980 using pictures of both the house martin and the oyster catcher and with both black and white children of the same ages as in Sweden. There was no difference between black and white children. However, a difference was noted between boys and girls. The girls preferred “soft” image shapes to a greater degree ($p < 0.05$).

On a subsequent occasion, I had 79 adults (12 women and 67 men), participants in a Scandinavian audio-visual conference, rate the two image subjects in all the croppings except for the “free” shape. Ratings were made on a scale of 1 to 5 (very poor–very good). The pictures were projected on a screen in a conference room. Each picture was displayed to all participants for 12 seconds. The “soft” image shapes were always rated higher than the images framed by straight lines ($p < 0.05$) however, the differences were not as pronounced as with the children.

To assess image contents

In one study (Pettersson, 1985) 46 “senders” as well as 80 “receivers” assessed image contents. Results showed that for seven out of ten pictures there was a significant difference between the intended and the perceived image content. The above pictures were all mounted on cardboard paper in the A3 format (29.7 x 42.1 centimetres). In a follow-up study, slides were made of the five drawings. These slides were then shown to and rated by 113 adult subjects at the UREX image laboratory in Finland.

In the first study, a semantic differential scale was used. The verbal ratings “very poor,” “rather poor,” “neither poor nor good,” “rather good,” and “very good” were supplemented with a numerical value from zero to one hundred. For practical reasons, a Likert scale (“very poor,” “rather poor,” “rather good,” and “very good”) had to be used in the second study. Thus results from the two studies are not exactly and immediately comparable. However, these two studies show a remarkable similarity of results. In both cases pictures were rated very much the same. In this case it can be concluded that content was more important than format.

McDougall and Hampton (1990, p. ix). noted that photography, despite common belief, is not a universal language. Viewers react to photos very personally. They interpret them in terms of their cultural heritage and environment. A photograph, therefore, may not communicate the same message to all viewers. Weidenmann (1989) studied under-evaluation of pictures. In an experiment, 206 male undergraduates rated the “perceived quality" of five materials on leadership. The five versions were:

- Text.
- Text with "imagination instructions."
- Text with pictures and no instructions.
- Text with pictures and picture-oriented instructions.
- Text with pictures and imagination instructions.

The "illustrated text with picture-oriented instructions"-group rated the material more positively with respect to the following dimensions: comprehensibility, concreteness, attractiveness, and 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. Pictures need captions.

Where do we look?

In one opinion poll 93 information design students were asked to 1) look at two food packages, and then 2) draw circles on a reply form, with images of the packages, to show were they first had looked at each package. The two packages each displayed four information elements; one pictorial and three verbal:

- A picture of the contents.
- The name of the product, a title.

- The trademark.
- The amount of contents in the package.

Only one of three subjects (33%) first looked at the pictures on the packages. Two of three (67%) first looked at some verbal information. Most of the 186 observations (42%) were on the name of the product. The trademark was the third group (23%), followed by the amount of contents in the package (2%).

To create images

In four different experiments, art and design students in Sweden have been assigned the task of making pictures according to various instructions (Pettersson, 1984, 1985, and 1986a). These experiments resulted in a variety of pictures (almost 600). There is no doubt that an intended content can be expressed using many different images. It is also quite clear that different people perceive and depict a given text in widely differing ways. Content is more important than format.

In visual language, non-meaningful basic elements (dots, lines, and areas) are put together into shapes that are combined into syntagms or sub-meanings (Pettersson, 1987b). Syntagms can be part of complete meanings that in turn can be sub-meanings to other complete meanings. The basic elements can be put together in different ways, thus forming different images.

In an experiment, subjects were given three sets of basic elements. They were given the assignment “Combine the basic elements on each piece of paper into an image.” The efforts resulted in 165 pictures. According to image contents, the pictures were grouped in various categories. Contents comprised groups like eye, cat, bird, face, animal, person, and also abstract ones. The basic elements had been produced by taking original pictures apart electronically. The elements were mixed in a new way and some got new orientations before they were printed out in hard-copy formats. It can be concluded that a given set of basic elements can be combined to form various completely different images.

The same subjects were also given a picture in which they were asked to use white ink and eliminate one hundred dots without changing the image contents. They all succeeded. Results fully confirmed earlier findings (Pettersson, 1986c). We can delete, add, or shift information in an image without drastically affecting perception of image contents.

To illustrate a story

It is interesting to study the pictures in different editions of fairy-tale books (or movies). Different artists all have their individual styles of work. They also have their own ideas of what to select and how to emphasize interesting contents. It is an obvious fact that our perception of a story is very much dependent on the illustrations that are selected. In one experiment an organization, Illustratörcentrum, for illustrators in Sweden, gave their members a short story by a well-known author (Illustratörcentrum, 1990). A total of 57 artists created illustrations to the text. All the pictures were quite unique. In fact there were almost no similarities at all between the different images.

To produce informative materials

In one experiment (Hellspong et al., 1987) groups of students at the University of Stockholm were assigned the task of producing informative materials in different versions. After production, senders as well as receivers assessed all the 29 versions of information materials according to the 0–100 semantic differential scale. Results showed that there were major differences between intended and perceived levels of quality for the four examined variables “text,” “visuals,” “graphic design,” and “total impression.” The average level of intended quality was higher than the perceived levels (m = 22.5), i.e., the senders rated their material more favourably than the receivers. Perceived quality was better than intended quality only in about 15 percent of all 116 group assessments.

To produce information graphics

IFRA Institute (in Darmstadt, West Germany) organized a workshop “ Infographics” (Nov. 29–Dec. 1, 1988). Twenty journalists, artists, and graphic designers from different newspapers participated in the workshop. They worked in eight groups with two to three persons in each. All groups had computer equipment and they worked with the same theme. The workshop was concluded with evaluations of the information graphics that had been produced. Copies of all graphics were distributed to all groups together with evaluation forms.

Each graphic was assessed according to ten different criteria. A combined five grade numeric and verbal scale was used: 1 = not satisfactory, 2 = satisfactory, 3 = rather good, 4 = good, and 5 = very good. The ten criteria were: 1 = legibility of text, 2 = legibility of image, 3 = foreground (should be clear and distinct), 4 = background (should not be disturbing), 5 = text-image connections (should be clear), 6 = location of places and/or events, 7 = documentation of facts and/or explanations, 8 = presentation of statistics, 9 = editorial comment/s, and 10 = overall aesthetic value.

Results showed that all criteria were assessed in a subjective way. In fact most of the grades were used for all criteria. This was true for all graphics. The eight graphics form three categories. One graphic has a concentration at the high end with

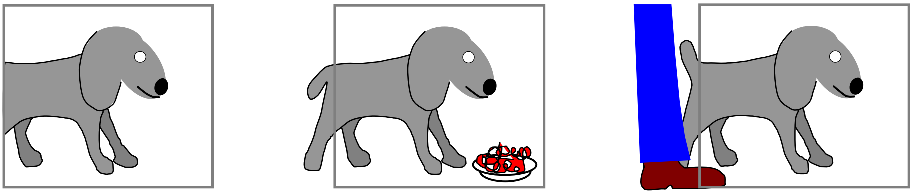
80 percent of ratings good and very good. The contrary is true for two graphics. They have a concentration at the low grades with 80 percent of ratings not satisfactory and satisfactory. The remaining five graphics have an even distribution of grades or a week concentration at the middle of the scale. It can be concluded that subjects have different opinions about information graphics.

Describing picture context

In communications, the sender is anxious for different receivers to perceive her/his message in the same or at least in similar ways. But this is seldom the case. Major discrepancy between the sender's perception and the individual receiver's perception is very common (Pettersson, 1989). A picture always represents a choice among several alternatives. A picture represents a "frozen" slice of time. Something is always going on around, before, and after a depicted event.

In one experiment (Pettersson, 1989), adult subjects were asked to draw pictures depicting events in the enclosed field around six small and simple illustrations. They were also asked to draw pictures depicting the events they considered to take place "before" two and "after" two pictures. Subjects also wrote explanatory captions. The subjects drew a total of 378 pictures and wrote the same number of captions. As expected, subjects had very definite and differing opinions about what was probably going on around particular pictures and about events prior to or after a depicted situation.

This experiment has been repeated (Pettersson, 1992) with four of the original pictures ("cat," "dog," "boat," and "cloud"). The first two of these pictures refer to the question of around. The other two refer to the questions of before and after respectively. The results of this experiment confirmed the results from the first study.



Here are two examples of results of "around the dog image" (left). In the first example the dog is completed and given some food. In the second example the dog is completed and leg of a human is seen to the left.

For the first assignment, 120 subjects drew an average of 49 different depictions of the picture's contextual events. The most common motif was selected by an average of 16 persons. Most subjects (71%) ignored the inner frame when depicting context. However, the inner frame was utilized as significant image element in the composition of 69 pictures. The inner frame was then incorporated as, e.g., a window, painting, poster, book page, aquarium, or cinema screen, to mention just a few. Context therefore governed the size of the original motif.

Regarding the second assignment, 120 subjects produced an average of 29 depictions of events preceding and following each stimulus picture. On average more than one subject draw 18 different motifs. 18 individuals selected the most common motif. The results showed far closer agreement between the subjects' perception of events "before-after" than of events "around." The latter produced fewer motifs (29 vs. 49). In addition, the most common motif was represented in more pictures (24 vs. 18). However, the number of motifs drawn by more than one subject was about the same for both assignments (16 vs. 18).

The results show that the subjects have treated the visual information in a conscious and analytical manner. The results suggest that each subject placed available information in a wider, expanded, “personal” context. All the interpretations were realistic and about equally credible. We are apparently capable of sensing far more information than is explicitly displayed in a given picture. Adult perception tends to be holistic rather than detail-oriented. No one, except the original picture creator, can state with absolute certainty what is really going on around a particular picture’s events or what really happened before or after the situation depicted in a selected picture. All the subjects still expressed opinions about circumfluous events on their drawings. They also tended to feel that their particular interpretations were the correct ones.

Image-enhancement graphics

Vogel et al. (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.

To understand diagrams

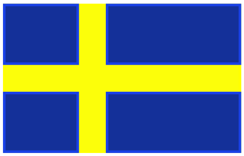
Lowe (1992) studied how experts and non-experts processed information provided in weather maps. The results indicated fundamental differences between how experts and non-experts represented diagrams mentally. The nature and extent of these differences indicated that the non-experts lacked a suitable basis for processing the diagrams in a way that would help them learn about the discipline. Their mental representation was impoverished, fragmentary, and mainly based upon superficial visuo-spatial characteristics of weather map diagrams' pictorial constituents. The non-experts' mental representation was limited to the particular diagram under consideration and lacked the scientists' highly interrelated and hierarchical structure between different types of information.

The research showed that the task of processing diagrams may not be as different from the task of processing other types of presentation as might be supposed. Individuals lacking experience in a discipline will have a limited capacity to make effective use of diagrammatic presentation. Diagrams cannot be regarded simply as an alternative form of presentation that is easier to process than drawings and photographs.

Perceptual constancy

A country's flag is often its most prominent national symbol. The flag is devised according to a specific pattern with specific colours and proportions. There are usually very strict rules about the times when the flag may be hoisted and lowered. Children quickly learn to recognize their country's flag. This is evident in the spontaneous drawings made by children in different countries.

Yet even though most people learn to recognize their country's flag at an early age, they would probably still be incapable of supplying an exact description of the flag's appearance. But we are still capable of recognizing our flag when we see it, irrespective of the way wind may change its shape or weather conditions alter its apparent colours. Perceptual constancy generally prevails for flags and many other symbols. In our mind's eye, objects tend to retain their shape, size, brightness, and colours, irrespective of the distance, angle, or lighting conditions from/in that we view them.



We will recognize our national flag from any distance and from any angle and still get the same perception. This is perceptual constancy. Here we have a combination of colour constancy, contrast constancy, shape constancy and size constancy.

In another experiment under my leadership, Paukstadt (unpubl.) used an A4-sized paper to which a blue-yellow-blue strip was glued. The strip had the same colours and width proportions (5:2:9) as the Swedish flag and was equivalent to less than 4% of the area of a normal flag. The blue-yellow-blue strip inspired 91 students (65%) to think of the Swedish flag. The other 50 students in the study (35%) thought of no less than 27 different subjects. The results showed very clearly that even a highly deformed flag symbol was often capable of generating associations with the national symbol. There is a large degree of perceptual constancy.

Approaches to picture perception

There are many approaches to picture perception. Based on the theory of linear perspective, invented during the Renaissance, Gibson (1971) defined picture perception as a stimulus-driven process in which information is picked up from optical arrays. Gombrich (1969) and Gregory (1978) held the opposite view. While seeing a picture the viewer constructs a meaning based on experience and expectations. From this receptionist position neither the readers nor the message remains the same. Meaning exists only for a moment within each individual reader.

More approaches

Another approach to picture perception is based on semiotics and symbol theory (Goodman, 1976). Intentionalism suggests that a producer, leaving the reader to discover and unfold it, embeds meaning in the message. From this perspective meaning exists independent from the reader. For an intentionalist a painting means what the artist says it does. For a receptionist the painting does not mean anything until the reader says it does (Muffoletto, 1987).

Boeckman (1987) makes a clear distinction between drawings and paintings, which have "signs" and photographs that have "recorded perceptional stimuli." "Before photography was invented there were two modes to learn about reality. Perception is processing stimuli of the surrounding reality on the one hand and communication is processing signs on the other. Now we have something in between: "Recorded perception stimuli which are not reality but not signs either." For Arnheim (1974) picture perception is a matter of responding to basic forms such as gestalt laws. An important point of Arnheim's is that visual perception includes the same behaviours that we commonly consider only as matters of cognition or thinking. A “percept” is a building block of visual thinking and as such is analogous to the cognitive function of a concept.

Lowe (1992) used weather maps in a series of experiments and found that experts formed resident mental representations different from non-experts. Resident mental representations are considered to be the overall outcome of a person's experience with subject matter that is relevant to a task to be performed. The non-experts used a largely data-driven approach, relying primarily upon the obvious visuo-spatial properties of the graphic elements comprising the display. In contrast, the experts went beyond the literal characteristics of material given explicitly in the display and used a domain-specific, representation-driven approach. These fundamental differences in approach were interpreted as evidence for the dominance of a visuo-spatial based mental representation for the non-experts and meteorologically based semantic mental representation for the experts.

Overview and analysis

Some researchers suggest that information is represented solely in the form of propositions. Images are said to be recorded into propositional format by a series of transformations (Pylyshyn, 1973, 1979). Others suggest more complex systems in which a variety of storage formats co-exist in an interlinked manner (Anderson, 1978, 1983; Wender, 1989). The perception process is often assumed to consist of two stages. A fast overview is followed by a conscious analysis. When we first look at an image we only see that which is necessary to perceive and identify objects and events in a reasonable and meaningful manner. This is Gibson’s “principle of economy” (Gibson, 1966).

As previously noted Barry (1998) makes a clear distinction between two independent mind systems, one that feels and one that thinks. This explains why images may speak to us holistically and emotionally. Data about some images are only emotionally processed. Other images are analysed. In rational theory, people weigh things equally and then consciously decide on truth or logic. In reality, however, emotional response comes first. Barrry concluded we begin to respond to the visual environment emotionally, below the level of or rational awareness, before we can critically analyze it. This makes it likely that much of cognition is actually rationalisation to make unconscious emotional response acceptable to the conscious mind.

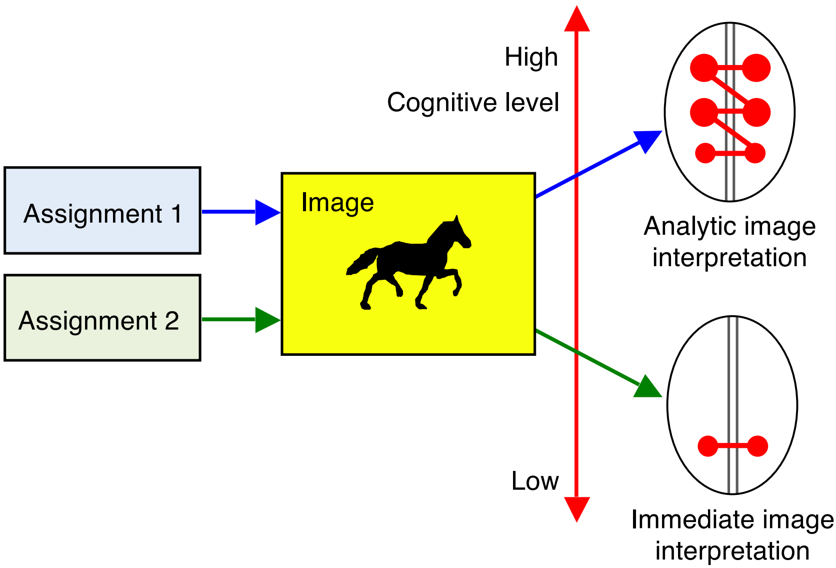
I have presented a similar “dual view” (Pettersson, 1987a) when I found that simple line drawings accompanied by various assignments caused very different reactions in subjects (see figure). It is obvious that the different assignments have caused perception and image interpretation on different cognitive levels. I suggested that image interpretation on low cognitive levels follows these steps:

1. The subject looks at the image. A few rapid eye fixations are made.
2. The information is handled as a “whole” in parallel, simultaneous, tentative, rough, holistic, and fast processing.
3. A “wholeness interpretation” occurs, recognition, and meaning of the image content is formed very quickly – “immediately”.
4. This interpretation is expressed by the use of a very limited number of words.

I also suggested that image interpretation on high cognitive levels follows these steps:

1. The subject looks at the image. A few rapid eye fixations are made.
2. The information is handled as a “whole” in parallel, simultaneous, tentative, rough, holistic, and fast processing.
3. A “wholeness interpretation” occurs, recognition and meaning of the image content is formed very quickly – “immediately”.
4. Certain details in the image attract more eye fixations.
5. The information is processed again, maybe several times, detail by detail. The process demands attention and is sequential.
6. Our verbal memory is activated in a search for suitable expressions. Various hypotheses about the image content are weighed against one another and tested. Segmented codes have to pass through several levels of recognition and interpretations before meaning occurs.
7. The interpretation of the image contents is expressed by the use of a large number of different words.

In both cases, I believe, both halves of the brain are involved in the interpretation of image contents. In the first case there might be a dominance of right brain activity. However, in the other case there might be a dominance of left brain activity. Interpretation of verbal visual information such as a television-program is likely to take place simultaneously in both parts of the brain.



An image is interpreted in different ways depending on the assignment (Pettersson, 1987a). An immediate image interpretation is handled on a low cognitive level. An analytic image interpretation needs high cognitive level activities.

Picture perception conclusions

How we actually create meaning is an area where much research still is needed. It can be concluded that:

- All visual experience is subject to individual interpretation.
- Perceived image content is different from intended image content.
- Different assignments may cause different interpretations of image contents.
- Some assignments cause interpretation of image contents on a low cognitive level.
- Some assignments cause interpretation of image contents on a high cognitive level.

- Even simple pictures may cause many different associations.
- Each receiver will place available information in a wider, expanded, “personal” context.
- A given set of basic elements can be combined to form completely different images.
- The design of a picture can be changed a great deal without any major impact on the perception of the image contents.
- Content is more important than execution or form.
- Picture readability is positively correlated with both aesthetic ratings and assessed usefulness in teaching.
- 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.
- There seems to be no major difference between gender in interpretation of image contents.
- Students display poor pictorial capabilities.
- Most subjects have their own ideas on how to finish a story.
- There are major differences between intended and perceived levels of quality in informative materials.
- We must learn to read image content.
- How we actually create meaning is an area where much research still is needed.
- Guidelines to visual artists will usually not lead to destruction of creativity.

Pictorial style preferences

Many observers have noted differences in visual perception and pictorial conventions between people in less technologically developed countries and those in the industrialized, European cultural sphere. On closer examination these differences appear to be related to cultural factors rooted in geographic location as well as in level of technological development. These perceptual differences have educational implications, as Stacey (1969), Arnheim (1974), Chaplin (1971), Duncan, Gourlay, and Hudson (1973), and others have pointed out.

Like a text, a picture can be produced in various styles. Illustrative or artistic pictorial style can be defined as the mode of expression employed by an artist in interpreting pictorial content. Sloan (1971) discussed four pictorial artistic styles: photographic, representational, expressionistic, and 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.

Literature on preferences for pictorial artistic styles fall into three primary groups studies in which subjects selected a preferred picture from a series of pictures, in isolation from any accompanying text studies in which subjects selected a picture which they felt best illustrated accompanying text and studies in which subjects were asked to supply verbal reasons for their picture preferences. Several researchers (e.g., Rudisill, 1951-1952; Lam, 1966; Sloan, 1971; Lindsten, 1975, 1976; Myatt and Carter, 1979) concluded that children preferred realistic art styles.

However, Ramsey (1982) concluded that primary age children preferred photographic as well as cartoon art styles, when they selected pictures in isolation from text. According to Pettersson (1990), teachers as well as children regarded colour photographs showing what things look like, drawings as complements to photographs, authentic, historical pictures, and authentic pictures of works of art as examples of "good visuals." "Fussy" overviews, abstract, obscure, ambiguous pictures, or pictures lacking the necessary facts were regarded examples of "poor visuals."

Poor visuals display prejudice and attitudes in conflict with democratic principles. Pictures with merely a decorative function and "educational cartoons" which fail to educate are other examples of poor visuals. And Lucas (1977) reported that fifth grade children preferred "impressionistic" art with captions and photographic art with biography.

Like Sloan (1971) and Lucas (1977), Ramsey (1989) concluded that children equate highly realistic art styles (photographic and representational) with text content that depicts reality and real-life situations. Ramsey also found that children were very consistent in equating the more abstract art styles (expressionistic and cartoon) with imaginative, "pretend" or "make-believe" literature. Rank scores for the pictorial styles for 173 subjects were photographic (1.08), representational (2.01), expressionistic (3.16), and cartoon (3.75).

In the interpretation of artistic style even children, as young as first grade, are visually literate. According to Ramsey, children like to read about real-world subjects illustrated with full-colour photographs, and they like to read about imaginative subjects illustrated with cartoons. This research suggests a complex interaction between children's perceptions of artistic style and their selection of style to accompany specific literary forms. Ramsey suggests that children employ pictorial artistic style as a yardstick for measuring the reality or fantasy of accompanying content material. Artistic styles may therefore give children various "pre-understandings" of the text contents.

Lines and shapes

The things we humans perceive in a visual field and the manner in which we interpret image content depend greatly on whether or not the image is familiar within our society and whether proper interpretation of the image has survival value within our particular culture.

Turnbull (1961) provided a vivid example of the effect of physical geography on size and depth perception. He described how huge buffalo were construed by a pygmy, accustomed to living in a dense jungle, as being no larger than insects when he viewed them from a distance on a savannah. In the jungle it is impossible to see any animal at anything but relatively close range, and thus it is difficult to develop anything but close-up perspective.

Pygmies are renowned for their great skill in detecting and killing birds and monkeys hidden in jungle foliage. Likewise, Eskimoes are skilled in detecting a polar bear or a seal in arctic terrain. In either environment a European would have difficulty spotting anything at all.

Lanners (1973) found that "primitive" people dislike straight lines or rectangles in pictures. Annis and Frost (1973) have shown that Cree Indians in Canada fail to perceive rectilinear optical illusions in the same way other Canadians do. Accodring to Allport and Pettigrew (1957) this is also the case for the Zulu, a Bantu nation of southeastern Africa. The explanation in both these cases is believed to be that "primitive" people prefer naturally rounded shapes. The environments of "primitive" people almost invariably feature rounded, gentle contours. Their homes are built as oval huts.

It takes only a glance at a painting by Brueghel to see how completely European rural and urban landscapes have been transformed since the 16th century. In that century, European towns had basically soft contours. Nowadays, new city streets are laid out in angular, abstract networks. If a hill is in the way of a new street, the hill is simply blasted out of existence. The ensuring rubble is then used to fill in valleys or lakes. Modern cities are dominated visually by the squares and rectangles of contemporary building modules. Similarly, new fields and forests are laid out in regular, geometric patterns rather than designed to follow the natural irregularities of the original landscape contours.

According to Segall, Campbell, and Herskovits (1966), it was in the 1880s that a rectilinear view of the world began to influence European perception and interpretation of visual fields. They pointed out that one of the most striking things about a photocopy is its rectangular shape and its white frame. These properties may very well have an effect on and interfere with our perception of the image subject. This supports the notion that physical geography exerts an influence on visual perception.

Image framing preferences

Influenced by various cultural conventions, Europeans of the late 20th century find it "natural" for pictures to be enclosed in rectangular frames, and even for the frames themselves to be decorated in some way. This preference is not necessarily shared in other cultures. The visual field of the eyes is actually in the shape of two partially overlapping ovals. The edges of that visual field are also blurred, not sharp. The retina's *macula lutea,* containing the *fovea centralis* with cells providing the clearest vision, is also oval. When illustrating his theories on selected visual fields, Gibson (1966) employed drawings of oval segments of reality.

Parallel lines and right angles never frame drawings that are made by "primitive" peoples. In the Stone and Iron Ages our forefathers made rock inscriptions and murals resembling pictures still being created today in other parts of the world. The ancient murals in northern Norway and Sweden deal mainly with mythical hunting scenes and depict such animals as moose, reindeer, salmon, whales, and seals. The rock inscriptions in southern Scandinavia, found most abundantly in Bohuslän County, feature ships, weapons, the sun, and people. There are also outstanding murals in the caves of Altamira, Spain, and Lascaux, France. Even though many of the murals were made more than 15,000 years ago, they retain uncommon vitality. The images follow the natural contours of the cave walls and are not subjected to artificial framing.

Illustrations in early European books frequently had gently rounded shapes. As late as the end of the 19th century Lloyds' Natural History (1896) was published in sixteen volumes with exquisite oval or "free" illustrations. Etchings, woodcuts, and paintings also were frequently made with oval or round shapes. At the turn of the century, oval photographic portraits were very common.

Nowadays, quadrangular frames are so familiar to Western viewers that they become aware of them only under unusual circumstances. Sporrstedt (1980) made the following observation about European influences in connection with the Stockholm exhibition of folk art from Tanzania:

> Naturally, pictures had been seen hanging on the walls of homes and offices of British colonial administrators and

other European residents. These pictures were invariably framed. For us the frame is a natural border for the picture image. But for the African servants in Oster Bay villas near Dar-es-Salaam, the frame was an integral feature of the image. This is the way their first painters saw things, and the frame has remained an integral feature of art.

In summary, it may be that quadrangular pictures are largely the result of various technical dictates and are not a reflection of man's true, natural preference. As an informal test of this notion, I have, on various occasions, asked children and adults to rate pictures having different image shapes. Given more than 7,000 choices, both children and adults preferred "soft" images to those framed by straight lines. This preference is held true across different racial and ethnic groups.

Carrying this point into the educational realm, Jahoda et al. (1976) found that upper secondary school students in three African countries – Ghana, Kenya, and Zambia – learned the content of simple black-and-white drawings as well as students of the same age in Scotland and India. The pictures employed were of various animals and various types of human habitation. All the pictures were "free," that is, unrestricted by frames, tint plates, or the like.

Pictures in textbooks

If cultural-geographical differences do affect perception of image and colour, one would expect such variations to be reflected in the illustrations in textbooks designed in widely differing cultures. As a sort of pilot test of this hypothesis, I examined typical science textbooks, all aimed at the 10–12 year age group, from three different cultural areas: a less-developed African country – Ghana; an industrialized Asian country – Japan; and an industrialized European country – Sweden.

I found major differences in the pictorial treatment in the three textbooks. The Ghanaian book had 135 illustrations, all in colour. Only one illustration was a photograph; the remainder were drawings. The Japanese book had 347 illustrations, all in colour. Three-fourths of the pictures were photographs; one-fourth were drawings. The Swedish book had 250 illustrations, only a third of which were in colour. Half of the pictures were photographs; half were drawings.

Irregularly shaped, oval, or round image shapes were predominant in the Ghanaian book. Those pictures that were framed (an influence of Western printing traditions?) often contained oval or round subjects. In fact, more than nine-tenths of the pictures fit into one of these two categories. The Japanese book, too, contained a predominance of oval, round, or irregularly shaped pictures. In this case almost all of the round pictures were photographs of outstanding quality. The book displayed a highly refined image language with picture sequences illustrating various events step-by-step.

The pictures communicated a great deal of the content even to one unable to comprehend the Japanese verbal text. In the Swedish textbook fewer than one-fourth of the illustrations were “free” or rounded images. Two-thirds of the pictures were conventionally cropped into regular or, in a few cases, square formats. The layout of the photographs was frequently such that it was difficult to distinguish one picture from another. They were used for “visual effect” rather than for information transmission. The arrangement demanded readers greatly experienced in reading pictures. The drawings were made by several different artists and in a number of different styles.

In the Ghanaian and Japanese books, just as the drawings seemed to typify their respective cultures so did the use of colour. In the Ghanaian book all the pictures were simple, clear, and distinct, with a bright colour scale in which yellow and brown predominated. The other colours were largely the ones Berlin and Kay (1969) define as focal colours: red, yellow, green, brown, blue, orange, pink, purple, black, white, and gray. The Swedish pictures displayed a wide range of colours typical of the subtle colours of the Scandinavian landscape.

Subsequent interviews with representatives of African publishing companies in the Ivory Coast, Ghana, and Nigeria and examination of other textbooks from these publishing houses confirmed the observations made of the original small sample of Ghanaian texts.

Sibanda (2009, p. 202) argued that the textbook has a ubiquitous and pervading influence in the education of learners. Not even the advent of new technologies has been able to supplant this position. Coleman (2010, p. 199) noted that images, illustrations, and visual representations presently receive less attention than printed text as they relate to the creation of meaning in school.

Pictures showing people

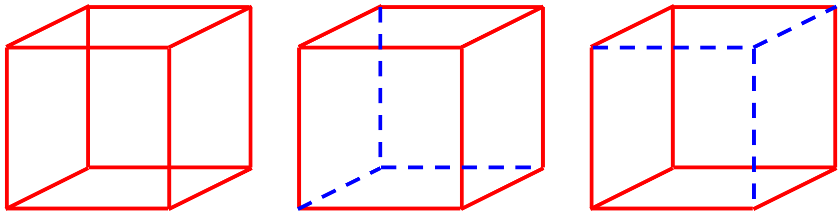
Generally speaking people like pictures showing people. Pictures are cultural products shared by many individuals (Moriarty and Rohe, 1992). An individual who is smiling in the picture is seen as a positive person, while an individual who is frowning is viewed as a negative person (Moriarty and Popovich, 1991). The larger a person's face appears in a picture, the more positively we perceive that individual. And a close-up headshot of a person is more positive than a photo taken from a distance (Archer et al., 1983).

When a person is shown straight on in a photograph he or she is perceived in a more positive way and perceived as being more in control of the situation than a person who is shown from one side (Moriarty & Popovich, 1991). This person is also perceived much more positively than persons who are shown from behind.

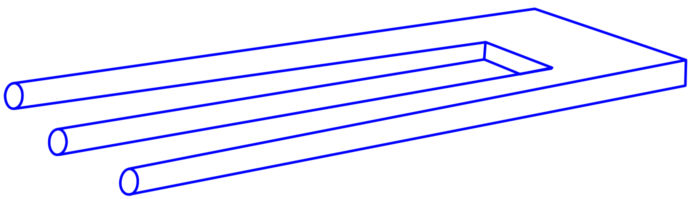
An individual appears powerful when he or she is photographed from below with the photographer looking up at him or her. The same individual appears less powerful, and least in control of the situation, if he or she is photographed from above. Individuals shown with closed eyes are viewed more negatively than those shown with open eyes. It is also known that the purpose of a photo is important for our perception of the person depicted in the picture (Moriarty & Garramone, 1986).

Illusions

One and the same stimulus can easily be perceived in different ways on different occasions. A very famous example of this is the Necker cube. It is perceived in one of two ways. There are many examples of "transformation" pictures of this kind. Some artists have become specialists in making pictures that which can be perceived in different ways. When the brain analyzes new data, it automatically adds or subtracts information in an effort to obtain a "sensible" interpretation of that data.

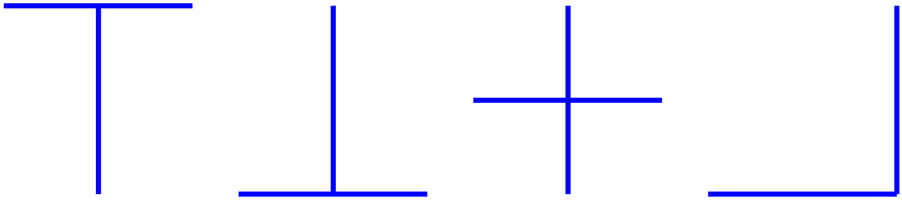


The Necker cube (left) is an optical illusion, first published in 1832. We can perceive it in two different ways.



This figure is "impossible." The depth ambiguity means that the eye is unable to obtain all the information necessary to locate all the figure's parts. The brain becomes unable to determine how to interpret the image (Thurstone & Carraher, 1966).

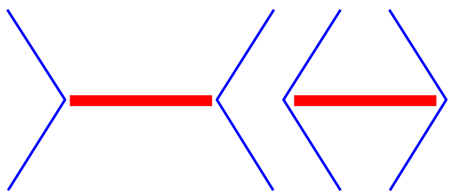
We often think that we see things that are not really there. Many viewers interpret the 24 blue scribbles as forming the word "information." An illiterate person would be unable to interpret the scribbles as forming a word (Pettersson, 1989).



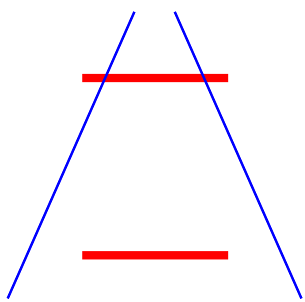
The bars are equal, but the vertical bar seems longer (Sarcone & Waeber, 2011). We often have difficulty in interpreting simple relationships. Horizontal lines are often perceived as being shorter than equally long vertical lines.

Open and light forms are perceived as being larger than closed and darker forms of the same shape in the same size (Thurstone & Carraher, 1966).

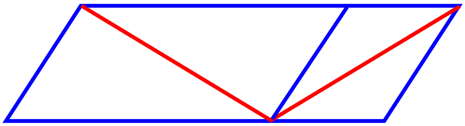
The left figure seems to have a longer horizontal line than the right figure. This is the Müller-Lyer illusion (from 1889).



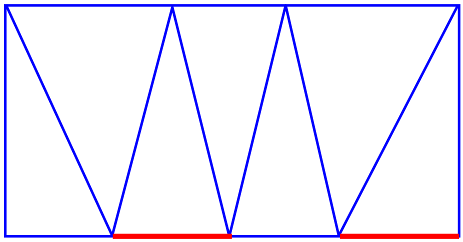
The left vertical line seems to be longer than the right verti cal line, but they are the same. This is the Ponzo illusion (from 1911). (Sarcone & Waeber, 2011.)



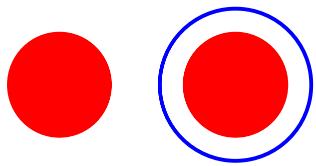
The Sander illusion, or Sander's parallelogram, is an optical illusion from 1926. The left red diagonal seems to be longer than the equal diagonal to the right.



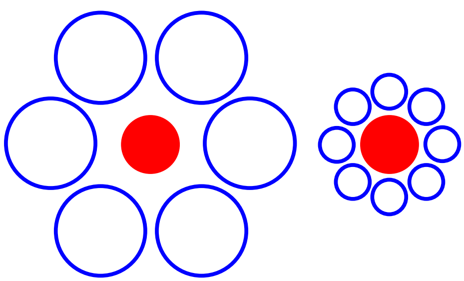
The left horizontal red line seems to be *different than the right red line, but they are the same. This is the Fee illusion (Sarcone & Waeber, 2011).*



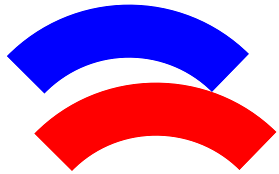
The two red circles have the same size but the right circle appears larger. This is the Delboeuf illusion. (Roberts et al., 2005.)



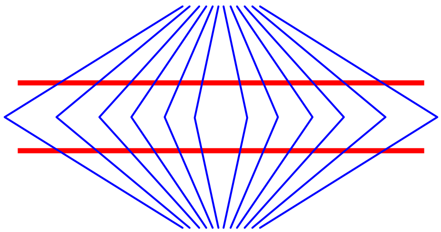
The two red circles have the same size. This is the Ebbinghaus illusion or Titchener circles (1901). (Roberts et al., 2005.)



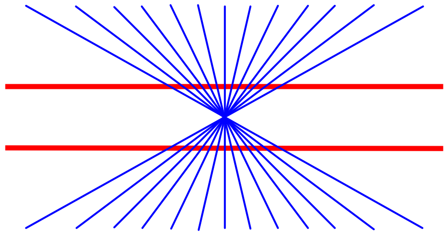
These two ark shapes are identical. This is the Jastrow illusion (from 1889). (Sarcone & Waeber, 2011.)

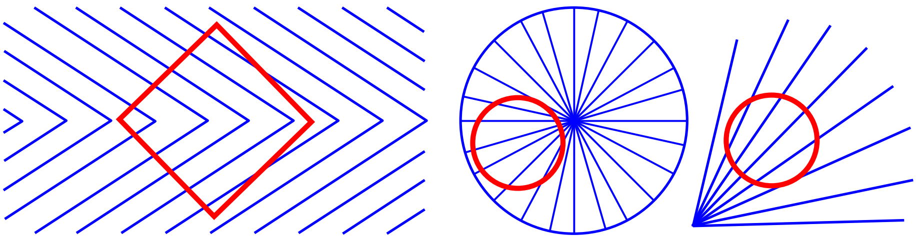


Intersected straight lines no longer appear to be straight but bent or serrated. The red lines are parallel. This is the Wundt illusion (19th century).



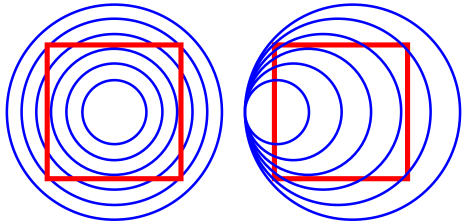
Intersected straight lines no longer appear to be straight but bent or serrated. The red lines are parallel. This is the Hering illusion from 1861.



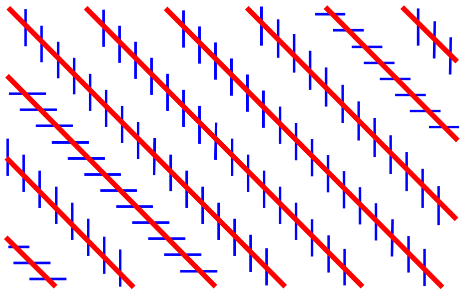


The tilted square no longer appears to be a square, and the intersected red circles no longer appear to be circles. This is the Orbison illusion from 1939 (Finemark, 1996). This is a variant of the Hering and Wundt illusions.

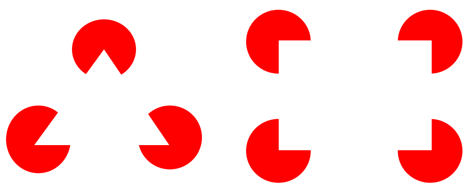
The Ehrenstein illusion from 1941 is an optical illusion. Here perfect red squares that are located within a pattern of circles take apparent curved shapes.

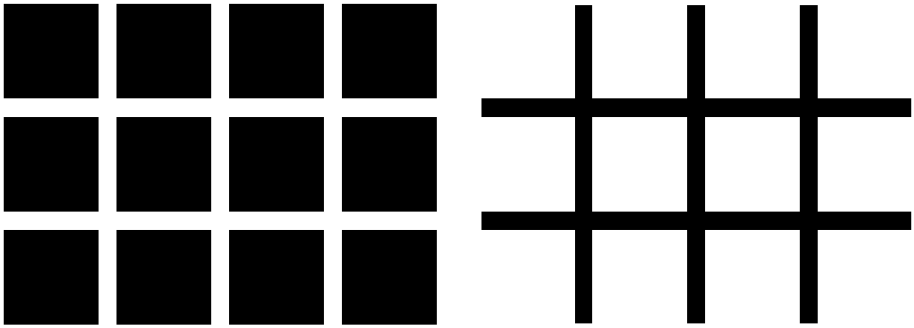


All the red lines are parallel. All the smaller horizontal and vertical blue lines distort our perception. This is the Zöllner illusion (1860).



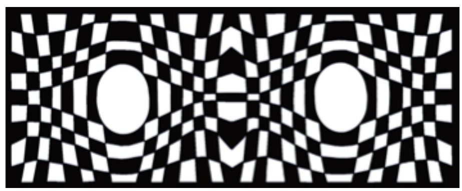
Our brains can create a con tour where non exists in the image. Kaniza (1979) de scribes such illusory contours as examples of modal, or visible completions.





In regular patterns like these the areas in the intersections of the white and black lines look gray. The total black and, respectively white area must be considerably larger than the white and, respectively blue area for phenomenon to arise (Thurstone & Carraher, 1966).

Changes in scale give an illusion of elevations or depressions ina flat figure. Inspired by the painting Metagalaxy by Victor Vasarely 1960-61.



Perception and message design

Perception is a fundamental characteristic of life. In order to continue living, every organism has to perceive its environment and the changes in this environment. The concept of "perception" is a collective designation for the different processes in which an animal or a person obtains information about the outside world. Colours, illustrations, images, lines, pictures, sounds, symbols, texts, and words should be integrated in such a way that they can be interpreted as a meaningful whole rather than a number of individual elements.

In perceiving a message the receiver use sensory organs and the nervous system. When a message is internalized the receiver has got new emotions, new experiences, new feelings, and new knowledge. Often individuals will interpret the same representation in different ways. Here age and gender, cultural, economical, historical, political, religious, and social factors may be important. New impressions are interpreted against the background of our previous individual experience and learning. Experiences and assessments change over time and affect our way of associating. Messages that are contradictory often create more confusion than they provide help. The internalized message will influence the interpretation and understanding of future and related messages.

Facilitating perception of text

A text should be well worth reading for the intended receivers. In order to improve the reading value of the text the information designer can:

- Avoid irrelevant information and distracting jargon.
- Consider embedded meanings of different colours when using colours to accent words in a text (Hartley, 1987).
- Open and light forms are perceived as being larger than closed and darker forms of the same shape (Winn, 1993).
- Provide text with a rich language for pleasant reading.
- Use a list of contents to create pre-understanding.

- We can read a text from various distances and various angles and still get the same understanding of the text content (Pettersson, 1989).

Facilitating perception of pictures

Pictures should be well worth reading for the intended receivers. In order to improve the reading value of the pictures the information designer can:

- Cultural differences may impact the effectiveness of pictures (Kovalik, 2004).
- Open and light forms are perceived as being larger than closed and darker forms of the same shape (Winn, 1993).
- People find a "naturalness" in dealing with images either as an aid to or, in some circumstances, as the sole means of communicating (Lodding, 1983).
- Provide a good contrast between figure and ground in pictures (Wileman, 1993).
- Provide pictures with interesting contents (Pettersson 1989, 1993).
- Receivers have even more ambiguity or semantic diversity with visual images than with most expressions of written language with its manifold meanings (Limburg, 1987).
- Use photographs showing people (Archer et al., 1983; Moriarty & Garramone, 1986; Moriarty & Popovich, 1991; Moriarty & Rohe, 1992).

Facilitating perception of layout

The layout of information material may aid or it may hinder perception of the content. To aid perception the information designer should:

- Avoid too short and too long lines (West, 1987; Parker, 1988; Pettersson, 1989; Walker, 1990; Lipton, 2007).
- Make sure that distribution of space reflects relationships.
- Use colour, orientation, pattern, shape, size, texture, and value to show that objects belong together (Pettersson, 1989).

Facilitating perception of colour

People might see colours in the same way. However, no two persons experience colour in the same way. Thus the human reactions to colour stimuli cannot be standardised. Depending on age, culture, gender, and profession, there are different subjective reactions to colour. There are likes and dislikes of colour, based on general as well as personal associations. Colours should be used with care. In order to aid perception of colour the information designer should:

- Consider that many people are colour-blind (Hartley, 1987).
- Do not focus on specific colours as always best (Bradshaw, 2003).
- Do not use more than three or four text colours on the same page, screen, or slide (Pettersson, 1989).
- People rank colours as follows: blue, white, green, violet, orange, and yellow (Eysenck, 1959).
- Use colour and grey scale to influence the perception of size (Winn, 1993).
- Use colour to enhance perception of a visual message (Dwyer, 1978, 1985).
- Work to ensure good contrast between text and background (Bradshaw, 2003).

Processing and application

Learning is a general term for a relatively lasting change in performance caused directly by experience. Learning is also the process or the processes whereby such a change is brought about. Learning is a process or a set of processes by which relatively permanent changes in behaviour occur as a result of practice or experience.

The result of the learning process can be noted by observing changes in a person's or in an animal's behaviour. It can also be seen via neuro-physiological changes. The study of learning is one of the central themes of psychology, with connections to child psychology, physiological psychology, education, and therapy. The third step in the *Learning Helix* is called *processing*. The sensory organs and the brain work even when we are sleeping. In a normal life situation it is not possible to avoid learning. Most people are curious by nature.

After attention, perception, and processing of the information we apply our new knowledge and test it in different applications for confirmation. It is important to use new knowledge. We will remember relevant and meaningful information if we have use for it. The fourth step in the *Learning Helix* is called *application*.

The brain

Above the spinal cord is the brain. The brain is arranged hierarchically. The lower region, the brain stem consists of four parts: the medulla oblongata, the pons, the cerebellum and the midbrain.

The *medulla oblongata* regulates autonomic functions, such as control of movements and breathing. The *pons* contains circuits for basic movements. The *cerebellum* regulates the fine control of timing in movement and perception. The *midbrain* is involved with sensory and motor integration.

The higher region of the brain consists of the cerebral hemispheres, with such structures as the basal ganglia, the hippocampus, and the amygdala. The basal ganglia are involved in complex action sequences. The hippocampus is an important structure in memory and spatial behaviour. The amygdala is involved in the regulation of higher-order motivational states. The top layer of the brain is the cerebral cortex. This is the main region for complex thought and other intellectual functions. The cerebral cortex contains sophisticated circuits for the processing of sensory information and the execution of movement.

Different regions of the cerebral cortex have different functions. Vision is processed by the occipital lobes at the back of the head. Hearing is processed by the temporal lobes on each side of the head. The parietal lobes are important association regions that combine information from different sources. The frontal lobes are specialized for planning and execution of complex activities.

The modern era of brain research began in the mid-1960's, when Dr. Roger Sperry and his associates published their findings regarding patients who were operated on to control life-threatening epileptic seizures (see Gazzaniga & Le Doux, 1978; Levie, 1987, Sinatra, 1986; Wilson, Reeves, and Gazzaniga, 1982; for reviews). Metallinos (1997) noted that attentional and perceptual processes are neuro-physiological and basic biological activities of the sensory organs and the nervous system. All cognitive processes are mental activities. He concluded that in perception we see, hear, and taste fragmented bits of information. In cognition we see, hear, and taste cohesive and unified information.

Cognitive levels

Perception and thinking are activities that take place where no one can see them — inside our heads. Carlson (1993) pointed out that because thinking is hidden, we can only infer its existence from people's behaviour. When we think, we perceive, classify, manipulate, and combine information. When we are through, we know something that we did not know before. Much of our thinking involves verbal language. We use words and concepts, but we also think in shapes and images.

Two halves

In accordance with some theories, the two halves of the brain are apparently specialized and function independently of one another. At the same time, however, either of the brain halves appears to be capable of assuming the functions of the other half. There is an immense communication between the two halves of the brain. It has been estimated at six billion pulses per second.

Each half of the brain has its own sensory perceptions, thoughts, feelings, and memories. Thus, the left half of the brain is said to be mainly verbal: capable of speech, counting, and writing. The left half of the brain seems to be specialized in abstract thought. It is analytical, logical, detailed, and sequential. The right half of the brain is said to be speechless but it is capable of concrete thought, perception of space, and can understand complicated relationships. The right half of the brain is also said to be holistic, spatial, intuitive, and creative. According to Heilman, Chatterjee, and Doty (1995) the right half of the brain process information from global eye scans for overall orientation in space. The left half of the brain process specific information for visual cognitive activities performed close to the body, dependent on local eye scans of near space. These smaller, shorter, local scans allow sharp focusing and the identification of detail. Most certainly, there is considerable cooperation between the two brain hemispheres. Generally speaking, dual and parallel processing modes of the hemispheres are beneficial to the human being.

During processing of information, new groups of brain cells are activated and associate to each other (Dryden & Vos, 1994). Old and new information is processed in an attempt to find possible relationships or gestalts. Information is gradually converted into experience and insight. Experience and insight are then converted into knowledge. Later, knowledge is converted into skills and attitudes – and eventually into wisdom. The knowledge acquires more detail and is internalized. This process is influenced by our earlier experiences and memories (our internal context). The brain has 100 billion brain cells (neurons) and 900 billion supporting glia cells. Each neuron may be connected to other brain cells via more than 20 000 structures called synapses (Dryden & Vos, 1994). The brain cells communicate with each other by transmitting electrical impulses through this gigantic network, which is constantly changed and adopted to new situations.

Many estimates have been made of brain capacity. It has been said that the number of possible connections between the brain cells are greater than the number of molecules in the universe. According to Cotton (1995a) all those gloomy predictions that our brain cells have been decaying from the moment we were born have been refuted in some current research that suggests that brain cells can regenerate and that nerve cells can certainly grow again to give sensation to limbs that have been without sensitivity. The brain is sometimes described as a living jungle, far more advanced than any machine ever developed. However, the "cognitive science" approach compares the human mind with computers. Cognitive scientists generally model the human memory as a very complex network, where each piece of data is cross-linked, or cross-indexed, to many other pieces of data in many different places. Computers and computer networks are now being built to mimic this complicated arrangement.

Western societies have for a long time placed a premium on the properties represented by a well-developed left half of the brain. Intelligence tests are usually designed so that residents of urban areas consistently record higher scores on the tests than residents of rural areas; middle-class people record higher scores than blue-collar workers; and whites record higher scores than blacks. However, one study showed that Australian aborigines were dramatically superior to white Australians in solving test problems when these problems were designed so that the right half of the brain had to be brought into play in order to solve the problems. So, intelligence is linked to culture and cannot be defined with numerical values.

The right half of the brain is said to be more developed than the left half of the brain in boys. With girls it is the opposite. At school, children receive a good training of the left part of the brain. After a few years, boys catch up with girls with respect to the development of the left half of the brain and remain superior with respect to the right half of the brain. All children should be able to develop both parts of their brains at school. More right-brain activities, like drawing, handiwork, and rhythm exercises are needed. It is conceivable that some of the fantastic success noted by the Japanese in the field of electronics and computer technology is due to the circumstance that the Japanese, since time immemorial, have lived in a “pictographic” society and, therefore, think in a different way than we do in Western cultures.

Texts and pictures may be either easy or difficult to interpret, depending on different factors. If, for example, a reader lacks the background knowledge in a given field that is required in order for him to interpret a text, then there is no chance that he will understand it, no matter how diligently the writers, instructors, graphics experts, and designers exert themselves. The same applies if the reader's command of the language used is poor.

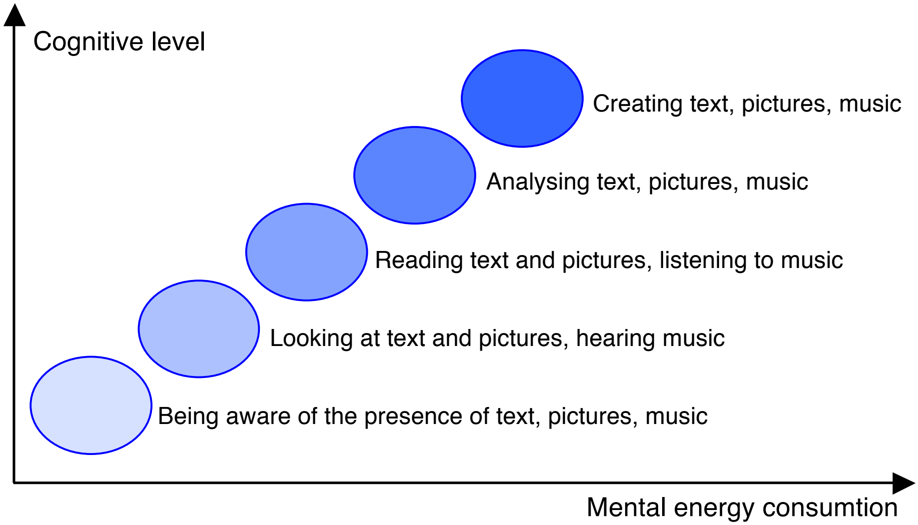
Salomon (1984) pointed out that there is a widespread naive preconception about pictures as “easy media.” Most people are convinced that pictures require only a small amount of invested mental effort to be understood. Weidenmann (1988) points out that a learner may quickly get an illusion of full understanding of the content or message in an image, and may stop the information processing after only a short glance. When the picture is combined with a text, s/he will concentrate on the part of the message that is perceived as the more informative. Text is generally perceived as a better medium than film for communication of to-be-learned content (Katz, Blumler, and Gurevitch, 1974; Kosbiech, 1976; Salomon, 1984). Weidenmann (1988) suggests that similar preconceptions may also exist about text vs. printed pictures.

See – look – read

An outline of a cognitive model to clarify differences between the concepts “ see-look-read;” and “ hear-listen” is presented in the illustration below. The model should be viewed as a theoretical device, based on empirical findings and extensive research on eye movements and fixations as summarized above, clearly showing that we are capable of perceiving picture contents in many different ways.

A single fixation of a picture is sufficient to enable us to recognize it subsequently among other pictures. If we, e.g., go shopping in a department store, we are virtually unaware of the large number of advertising pictures/messages and background music to which we are exposed to in the store. Everything merges into a kind of “noise.” We probably process most of the stimuli in this noise on a superficial level. We see and hear but do not look or listen. When we listen to the radio while engaged in some other simultaneous activity, such as cooking a meal, fixing a punctured tire, or glancing through a newspaper, we are aware of words, music, and images.

In a discussion on television narration Höijer (1998) concluded that fiction viewing might be regarded as a resting place for the mind. As a baby finds relief and solace from a comforter or a blanket, adults may find a solace in fiction viewing, but not in news viewing. In news-viewing our inner stream of thoughts is occupied with social reality and the public sphere. News-watching often is experienced as a social obligation, while fiction-viewing places few demands on us, and we may free ourselves from troubling thoughts.



It is suggested that there are different cognitive mental levels. Creating or analyzing a message needs much more mental energy than just looking at a message.

Looking at a picture consumes more mental energy and demands a higher cognitive level than merely seeing a picture. Visual impressions are conducted from the sensory to the short-term memory, i.e., operative memory. We only become aware of the information that succeeds in passing through the brain's filtering system. Most of the information disappears after a while. When we, e.g., study material in books or on TV, we process that material actively. We read texts, listen to music, and read pictures. Perceived information is processed, sorted, and stored in certain parts of the brain's long-term memory. Many fixations of a picture are required for people to recall it subsequently and, e.g., be able to describe it. Conscious analysis of linguistic messages, such as texts, music, and pictures (e.g., research), probably demands an even greater consumption of mental energy and a higher cognitive level. The brain actually uses about one fifth of our daily consumption of energy. The most demanding processes are those leading to the creation of text, music, and pictures. Creative people have often described the mental effort that is often associated with creativity. The model assumes the existence of a dynamic relationship in which we consciously and unconsciously switch cognitive levels.

Our sensory organs respond to changes in our environment. We are normally capable of resolving changes with a gradient greater than about two percent. But we adapt to slow, gradual changes and often fail to notice them. So our senses are normally in the resting state but have a rapid response capability. In the corresponding manner, we are unable to remain on the highest cognitive levels for more than relatively brief periods of time, since this would otherwise be too enervating and lead to some form of mental "cramp."

Like a pike lurking in the reeds or a cat poised outside a mouse hole, we know what our surroundings look like. When changes occur in those surroundings, we are capable of responding rapidly and powerfully by activating our bodies both in physical and mental terms. Sometimes, everything goes according to plan. The pike gets a minnow, the cat gets its mouse, and we find the information we are looking for. At other times, efforts may fail. A predator may miss its prey, and we may spend a great deal of time and energy gathering information that which turns out to be useless.

No clear distinctions can be made between the cognitive levels discussed here. But there are probably major differences between individuals due to cultural, social, and personal factors. So the model should not be interpreted too literally. However, it can be employed to elucidate the fact that there are major differences between the concepts “see-look-read” and “hear-listen.” Active reception of linguistic intelligence comprising text, sound, or pictures, individually or in concert, always requires exertion. Reading and listening are mentally and physically exhausting.

Uninteresting or poorly designed material reduces our interest in the subject described by that material. So the sender of a message should strive to design text, music, and pictures in the most attractive, relevant manner possible so receivers are encouraged to process the message on the highest possible cognitive level. This should be the case irrespective of whether the “message” involves “information,” “entertainment,” “education,” or “news.” The principles apply irrespective of the medium involved, although different media transmit messages from senders to receivers in completely different ways.

Compared to a book, an interactive computer programs, phonograms, films, TV, and video have a highly manipulative effect on receivers. Message contents change continuously in a predetermined manner with respect to subject selection, time, and space. The receiver’s active efforts to seek information are therefore largely disabled. A reader can “digest” the textual and visual contents of a book at a self-selected pace. In a structured information context, the reader is able to process information in about the same way as in a “natural” situation.

The aforementioned discussion could conceivably explain why pictures have such an impact and a much greater ability to influence us than a text. Children are more easily frightened by watching an act of violence on TV than by reading about the same act in a book or in a newspaper. This is because things we see appear to be more “real” than things we merely read about and because a higher cognitive level is required for reading than for seeing. Many scientists, such as Tröger (1963) and Noble (1975), have shown that small children are incapable of actively processing the contents of and understanding contexts in a TV or video program. This is something most parents of small children have also experienced.

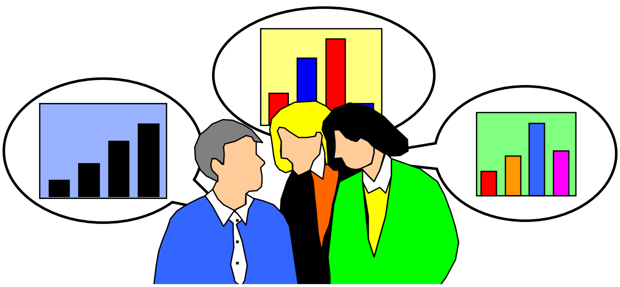
According to Blum (1986) the human mind functions on subconscious as well as on conscious levels of awareness and perception. The subconscious mind is readily accessible and receptive to various forms of suggestion and stimuli that can influence and alter conscious level thought and behavioural patterns. Our eyes are extremely sensitive to visible light wavelengths, visible light that is often not even seen, visually recording all that we see and do not see with exact precision. Blum maintains that there is an "unseen visual environment" which can and does provide suggestive stimuli to the subliminal level of consciousness.

Mental images

The terms image and imagery are used in a variety of situations. Derived from the Latin imago ("picture," "semblance," or "likeness"), an image is often thought of as a representation of what we normally perceive as the registration in our minds of an event, an object, or a picture. However, there are also several other meanings of the word image.

Let us see how this word is defined in a few contemporary dictionaries. The Longman Dictionary of Contemporary English (Longman, 1990) provides six definitions of the concept image. The Oxford Dictionary and Thesaurus (Tulloch, 1995) provides nine definitions, and The Random House Dictionary of the English Language (Berg Flexner, 1987), provides 23 definitions of the concepts image, imaged, and imaging and seven definitions of the concepts imagine, imagined, imagining.

All these definitions show that there are many different meanings of the words image and imagine. However, here I only discuss mental images (or inner images) as images formed in the mind; mental representations; ideas; and conceptions. Most people do not require any external stimuli in order to create mental images. We have an inner vision, a mode of awareness that dreams and creativity are made of. It is enough to think about an event, a specific object, or a person. Mental images can therefore represent both an "external reality" and an "internal reality." Here imagining is discused as the ability to form mental images. Visualizing is the ability to connect verbal information to mental images.



Our mental images are different. Each person creates his or her own mental images.

Dake (1999) noted that, in the scientific literature, visual cognition generally focuses on object recognition and classification and rarely presents any arguments in terms of visual images of aesthetic richness and depth. Visually simple diagrams, representing abstract intellectual theories, are the most common form of visual communication in the literature on visual cognition.

The perception of mental images may comprise many different combinations of impressions conveyed with the aid of all our senses. Our inner images may encompass everything from abstract stills to highly realistic, moving, three-dimensional images in colour plus a number of auditory, olfactory, gustatory, and tactile sensations. We may classify inner images according to the sense to which they appeal. Thus we have visual, auditory, gustatory, tactile, and olfactory images. We may also classify images by the sphere of influence from which they are perceived. Such examples are agricultural, domestic, political, religious, scientific, social, and technical images. Unlike a physical representation of an image, a person's mental representation is not directly available for scrutiny and study. Thus researchers of mental images must rely upon inference in order to characterize its components and structure. Inner images can be described to other people through drawings, film, paintings, models, sculpture, video, etc., as well as with words alone and without any physical representations.

In my view, there are two main types of inner images: 1) primary visual imagery and 2) secondary visual imagery. Gibson (1966) rejected the concept of the retinal image as a picture. We are never conscious of the process in which rays of light reflected from some object enter the eye, are refracted by the eye's cornea, lens, and vitreous humor, and strike the retina. The retinal images, that are formed upside down on the back of our eyeballs are very unstable, and abruptly shifting two to four times every second according to the movements of the eyes. They are continuously translated into signals sent through the optic nerves to the visual centres in each half of the brain.

There, primary visual imagery, i.e., our perception of vision, is created in the brain's visual centres. This imagery is subsequently stored in our memories. (Also see section Vision.) All perceptual processes are neurophysiologic and basic biological activities of the sensory organs and the nervous system. All cognitive processes are mental activities. Metallinos (1997) concluded that in perception we see, hear, and taste fragmented bits of information. In cognition we see, hear, and taste cohesive and unified information. So primary visual images are the result of external stimuli. Most people, however, define the term "visual imagery" as something seen or experienced, roughly synonymous with the term "memory." In contrast to primary visual imagery, secondary visual imagery is mainly the product of internal stimuli. It is the mind that creates imagery codes which may or may not exist and which may or may not be recalled from memory. External stimuli can and do initiate secondary visual imagery. Memories are discussed earlier in this book. Thoughts and dreams are secondary visual images discussed in this chapter.

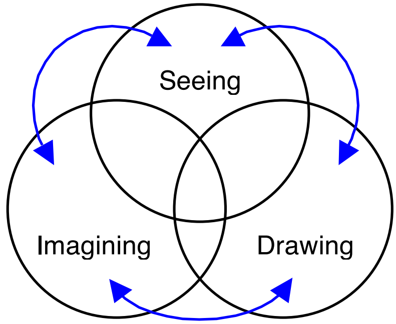
Visual thinking

Thinking is an activity that takes place where no one can see it — inside our heads. There has been a debate about mental imagery and visual thinking for many years. Visual thinking and visual thoughts are visual representations that arise when we think. Several researchers have provided definitions and theories about visual thinking. Arnheim (1969) was one of the first to use the term visual thinking. He described visual thinking as the unity of perception and conception that calls for the ability to see visual shapes as images (pictures, signs, and symbols). Paivio (1971) suggested that imagery uses representations and processes that are ordinarily dedicated to visual perception rather than to abstract conceptual structures.

However, Hinton (1979) and Kosslyn (1980) suggested that there are special processes dedicated to handle spatial information. According to Ruch and Zimbardo (1971) visual thinking, in its simplest form, is the manipulating of symbols representing elements of the internal or external environment by using imagery by formation of mental images. Wileman (1980) defined visual thinking as organizing mental images around shapes, lines, colour, textures, and compositions. And McKim (1980a, 1980b) defined visual thinking as the interaction of seeing, drawing, and imagining.

According to McKim (1980, p, 8): "Visual thinking is constantly used by everybody. It directs figures on a chessboard and designs global politics on the geographical map. Two dexterous moving men steering a piano along a winding staircase think visually in an intricate sequence of lifting, shifting, and turning... An inventive housewife transforms an uninviting living room into a room for living by judiciously placing lamps and rearranging couches and chairs."

The McKim diagram (1980b) explains the fluid dynamic that occurs without our conscious awareness or thought. The three partly overlapping 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.



The McKim diagram. Robert H. McKim (p. 8) illustrated the interactive nature of seeing, imagining, and drawing with a figure of this kind.

Stokes (2001) sees a connection between visual thinking and viewing graphics on a computer. Here complex computations are presented graphically, allowing for deeper insights as well as heightened abilities to communicate data and concepts.

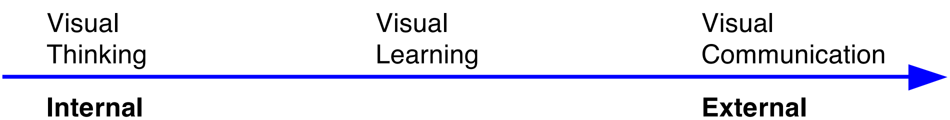
According to Dake (1999) science and art appear to agree on the fundamental importance of learning to perceive global, gestalt structure as foundational to visual thought. The visual materials that artists seem to regard as most foundational to the successful development of visual ideas are both global and configurational in nature. This preference corresponds to the function of the initial, primary occipital lobe, the visual processing areas of the brain. Both Segal (1971) and Holt (1972) have suggested that visual images may be described as a continuum based on the degree to which they correspond to external and internal reality. The recall of photographic reproduction or reconstruction of prior sensory experience may be considered as one end of the continuum, at the simplest level, while imagery more closely linked to internal reality may be placed at the other end. The notion of arranging different types of imagery along such an imagery continuum was explored and further developed by Hill and Baker (1983). They discussed six types of imagery "levels" or "classes":

1. *Static Imagery*. Memory images, "pictorial" representations in our minds of places we have visited, and of pictures we have seen.
2. *Construction Imagery*. The organization of non-visual sensory information into visual form. For example, forming an image of a person or an event.
3. *Transformation Imagery*. Active exploration and transformation of elements of a visual field. We may actively manipulate images of real objects, mental rotation of images. This kind of imagery is important in many activities, such as architecture, construction, interior design, and map-reading, where it is necessary to translate two-dimensional representations into three dimensions.
4. *Metaphoric Imagery*. We use visual metaphors and analogies in our minds. We are familiar with the primary image and we are required to make secondary conceptual links. Appreciation of a metaphor involves an understanding of the nature of the image and its function.
5. *Problem-Solving Imagery*. This is an extension of the fourth type. We perform intuitive synthesis involving extrapolation. We create new realities beyond our previous experience.
6. *Schizogenic Imagery*. This is a not fully defined end point on the visual imagery continuum. This kind of imagery is the product of an uncontrolled process and it is divorced from meaning. It is usually an indication of some kind of disturbance. This level includes hallucinations.

According to Pylyshyn (1981) imagery is not a distinct cognitive module but a representation of general semantic knowledge.

For imagery we use one general thought process. And Shepard (1981) proposed that in imagery a shape is represented by a two-dimensional manifold curved in three-dimensional space to form a closed surface, such as a sphere. It was suggested that each position within the manifold corresponds to one orientation of the shape, with nearby positions corresponding to nearby orientations.

Hortin (1982) added the dimension of visual rehearsal as a strategy for employing visual thinking in the learning process. Seels (1994) presented a “visual literacy continuum” reaching from internal visual thinking to external visual communication.



Barbara A. Seels (p. 106) illustrated a “visual literacy continuum” reaching from internal visual thinking to external visual communication.

Ausburn and Ausburn (1983) stressed the importance of the conclusion that emerges repeatedly from cross-cultural studies – that pictorial conventions are learned. Since people do not innately decode unfamiliar photographs, technical drawings, maps, and so on, they must first acquire the skills to make meaning from visual symbols. One example is the problem for people in developing countries to understand scale. Ausburn and Ausburn wrote (p. 15): “One major source of problems in interpreting scale is that an understanding of scale requires the presence of a direct system of measurement in a culture. Such a measurement system is lacking in the cultures of many developing countries, thus making the concept of scale a difficult one to teach and learn."

When research evidence indicates that skills in interpreting and formulating images and visual representations are learned or acquired skills, this also implies that they can be taught. According to Ausburn and Ausburn (p. 18) visual skills are increasingly vital in developing countries, as the policies of their governments call for increasing self-reliance. Richardson (1983) believes that all individuals have the capacity to form and use vivid memory images, but that some of them lose the ability through disuse and/or disinterest. However, Slee (1983) pointed out that while some people can recreate vivid pictures in the mind with little or no conscious effort, others are quite unable to muster up any kind of visual image in the waking state. Richardson (1983) distinguishes between two major kinds of images (p. 23–24):

> Thus, experiences which have their immediate origins outside myself are classified as percepts, while those that have their immediate origin within me are classified as images (Richardson, 1969).
>
> For every modality of perceptual experience, there is a corresponding modality of quasi-perceptual (i.e., imaginal) experience. Thus, conscious thought is represented in the form of images, but depending on the context of the thought and upon an individual's preference for representing it in one way or another, these images are likely to be mainly visual or mainly verbal (Richardson, 1977). While the content of a visual image is "pictured" to oneself, the content of a verbal image is "spoken" to oneself.

I agree with Richardson (1977, 1983) that while abstract thought tends to be represented in awareness by the sound and feel of inner speech, concrete thought is more likely to be represented in visual forms. (Also see the section *Modalities*.)

Despite these general tendencies dictated by the nature of the cognitive task, some people have such strong information processing preferences that they have been called verbalizers, if at one extreme, and visualizers, if at the other extreme. Slee (1983) found that mental imagery could be effective in retrieving appearance information (e.g., colour, brightness, texture, structural features), but less effective in recall of conceptual information (e.g., categories, verbal labels).

According to Kosslyn (1995, p. 268): "imagery is used to retrieve information from memory in a variety of circumstances, but primarily when 1) the information to be remembered is a subtle visual property; 2) the property has not been explicitly considered previously (and hence labelled); and 3) the property cannot easily be deduced from other stored information (for example, from information about a general category to which the object belongs)." The fact that activating visual memories can form images does not mean that there is only one process in use.

In fact there may be several different processes involved. Kosslyn (1995) noted that the simple fact that people can arrange imaged objects according to a description suggests that locations are processed separately from shapes. He noted (p. 272). "There is evidence for a distinction between two subsystems: one activates individual stored perceptual units well in both hemispheres, and another juxtaposes parts effectively only in the left hemisphere."

It is clear that a single "centre" does not carry out imagery. Imagery appears to depend on mechanisms located in different parts of the brain. The combinations of mechanisms that will be used depend on individual task. Actually Kosslyn et al. (1993) found that it was possible to track which parts of the brain are more active during one experimental imagery task than during another. By comparing brain activation when different images were formed in the minds of the subjects the researchers were able to show that topographically organized visual areas in the visual cortex were activated, and that the precise location of activation were depended on the sizes of the images. Two means of representation have been proposed for mental images: 1) depictive representations that confers a special status on images; 2) propositional representations that treats them as representations of linguistic meaning. These are different types of codes for storing (Kosslyn, 1980). According to Kosslyn (1995) imagery cannot rely solely on depictive representations (p. 292): "It is clear that depictive representations are one component of the ensemble of representations and events that underlie imagery, but they are not the only component." The brain is a very complicated organ with many functions and it is clear that a lot of research is still needed in order to fully understand visual thinking.

Creative work

Imagery is used when we reason about the appearance of an object when it is transformed, especially when we want to know about subtle spatial relations. Gardner (1983) found that we each have at least seven different types of intelligence. Two of these types, linguistic intelligence and logical-mathematical intelligence, are very highly valued in traditional education. The other five intelligences are musical intelligence, spatial or visual intelligence, kinaesthetic intelligence or physical intelligence, interpersonal intelligence or social intelligence, and intrapersonal intelligence or introspective intelligence.

Spatial intelligence or visual intelligence is the ability to paint, take great photographs, and create sculptures. People with visual intelligence create mental images, use metaphors, and have a sense of gestalt. They like to engage in drawing, painting, and sculpting. These people can easily read maps, charts, and diagrams. This is the kind of ability used by architects, sculptors, painters, navigators, chess players, naturalists, and pilots.

Blakeslee (1980) pointed out that even Aristotle, the father of formal logic, was aware that thoughts are dependent on images. In De anima (Eng. = On the soul), he wrote: “Thinking is impossible without some inner images. The process is the same when a person thinks as when a person draws a diagram.” According to Blakeslee (op. cit.), the American mathematician Hadamard (1945) found that distinguished mathematicians often avoid thinking in words. Instead, they employ visual imagery in their creative work. Hadamard reported that Albert Einstein once remarked that certain characters and more or less distinct, reproducible, combinable, consciously evoked images are the physical units that apparently serve as elements in the thought process.

Kosslyn (1995) noted that it is possible that the major use of imagery is to prompt one to think about previously neglected aspects of objects or events. Creative people sometimes witness that they are able to create with very few if any conscious thought processes. While design decisions are constantly being made, the design process is so fluid that thinking merely gets in the way. *The Artist In His Studio* is an interesting record of Alexander Liberman's visits to the studios of many of the great painters and sculptors who lived and worked in France during the twentieth century (Liberman, 1988). Liberman met with people like Braque, Cézanne, Chagall, Kandinsky, Léger, Matisse, Miro, Picasso. The book is an interesting source of the artist's working methods and different ideas. In 1954 Liberman met with Pablo Picasso (1881–1973) in his studio in Vallauris, a little hill town on the French Riviera. During the meeting Picasso made the following remark (p. 106): "I have an extraordinary memory. I remember practically all my paintings. The blue period was not a question of light or colour. It was an inner necessity to paint like that."

Picasso regarded his paintings as research and experiments, and not as works of art. In his different studios Picasso was "surrounded by an unbelievable mass of visual stimulants" (p. 105). Picasso collected everything that pleased, interested or inspired him. "I never move anything in a studio. I always leave everything exactly as it is," he said (p. 105). Liberman (op. cit.) had many conversations with Georges Braque (1882–1963) in his studios in Paris, as well as in Varengeville. In one discussion on painting Braque remarked (p. 143):

> The painting materializes in contact with nature. Painting is a meditation. It is contemplation, for the painting is made in the head. One must regurgiate it. One must give it back. Painting is a restitution.
>
> ... If I am going to paint a lobster, all I like to make sure of is whether it has six or four legs. Curious, the visual memory that one has. I did not know exactly how many legs a lobster had, but in drawing it from memory I found the cor-

rect number. I discovered that the memory of the appearance rendered the right number.

Several other authors have also commented on the creative work processes of painters. According to Girard (1996) Henri Matisse (1869–1954) once said (p. 10): “You see, when I paint, I am giving plastic expression to objects in my mind. When I close my eyes, I can see things better than with my eyes open, stripped of all incidental detail. That is what I paint.”

Liberman (1988) noted that almost all the colours that surrounded Paul Cézanne (1839–1906) in his Aix–en–Provence studio were gray (p. 5): “No one saw more colours in a gray than Cézanne. And the dark gray walls of his studio are the neutral background against which his eye translated the many hues of his inner vision. This great colourist also loved to paint on a gray day.”

In 1899 Cézanne painted the portrait of his art dealer Ambroise Vollard during numerous laborious sessions. According to Lallemand (1994, p. 80) Vollard reported that he sat 115 times and even then the painting (39.5 x 32 in.) was not yet considered finished. When Vollard drew the painter’s attention to two spots on the hands where the canvas was not covered, Cézanne responded that he had to find the right colour to fill these minute white spaces: “If I put something there at random,” the artist responded, I should have to redo the entire picture, starting from that very spot.” This dictum illustrates Cézanne’s intensive procedure and his unceasing concern for finding the right balance of form and colour.”

Authors sometimes claim to “see” their characters on some “inner screen” on which events are displayed. The Swedish detective story writer Gösta Unefäldt noted the following in an interview in the Dagens Nyheter newspaper (Ståhlberg, 1984; in translation): “When I’m sitting at my typewriter, it’s like having a screen in front of me on which all the action unfolds. The characters do things, and I just describe their behaviour.”

Other authors, film, TV and theatre directors, etc., have supplied similar descriptions of their creative work processes. Far too often the activities of creative people are thought to be motivated by pleasure and enjoyment only. Truly creative activity is extremely difficult work that often requires years of dedication and struggle in order to reach good results.

Problem solving

The mental representations that individuals generate for tasks are considered to have powerful influences of the way those individuals process external task information they encounter (Anzai and Yokoyama, 1984; Chi, Feltovich, and Glaser, 1981; Kotovsky, Hayes, and Simon, 1985; Larkin, 1983; Voss et al., 1983; Lesgold et al., 1988; Romiszowski, 1993). Geisser (1992) pointed out that we need words for logical reasoning. She concluded that a propositional/linguistic representation system is a necessary condition for logical inference and wrote (p. 181): “Images, or pictorial representations, can at best play a limited, heuristic role in logical reasoning, and more generally in the processing of thoughts. A pictorial/visual representation system, whatever its role in general cognitive processes may be, is a poor substitute for the verbal/linguistic system as a vehicle of logical reasoning.”

Qin and Simon (1992) discussed mental imagery in scientific problem solving. They concluded that similar information is displayed, whether obtained from the eye or from the memory. In both cases similar reasoning processes can be applied.

There may be less, as well as more, information in "the minds eye" than in a visual display. Our ability to reason on a display does not necessarily imply that we understand it. We cannot visualize two mutually contradictory scenes. According to Qin and Simon (op. cit.) the ability to reason from a display demands processes that are not simply "logical" but embed subject matter knowledge. A display may instruct the instructor but not the students, who do not have the same background knowledge.

When we form mental images they will usually fade away rapidly. Mental effort is needed to keep the images in place. According to Kosslyn (1995) many people have reported that (p. 276): "holding an image is a little like a juggling act: each part is refreshed while other parts are fading. Presumably, the total amount that can be kept in mind at once depends on the speed with which the parts are refreshed and the speed with which they fade".

Fantasy images

Fantasy is an imagined, generally pleasant, event or object. We create fantasy visual images by juxtaposing previously acquired combinations in new ways. Using our imagination, we can generate mental visual images of things we have never seen nor experienced before. Fantasy fulfils a wish or satisfies a desire whose ultimate origin is subconscious. According to Freud, our fantasies may be conscious, like daydreams, preconscious, such as cancelled plans, or subconscious, like proto-fantasies. A daydream is a flight from reality in the form of wishful thinking. During a daydream (see dreams), we are aware that events in our thoughts are distinct from events in the material world.

Conscious and preconscious fantasies are formed under the influence of subconscious fantasies. We utilize previous experiences and knowledge in a process in which we may well activate long-term memory, retrieve "copies" of visual elements, such as dots, lines, areas, shapes, patterns, etc., to the perceptive and cognitive level, and test different combinations in new ways. Thus we may "build" and form new inner images. Imagining the existence of fantasy animals composed of body parts and properties taken from a number of real creatures previously known to us is quite feasible. It is obvious that several painters and scriptwriters and producers of movies possess such abilities, which is clearly demonstrated by the "entertainment industry." This type of imagery represents an abstract "inner reality" and needs to have nothing in common with ordinary, everyday "external reality."

After visits with Marc Chagall (1887–1985) in his studio in Vence on the French Riviera Liberman (1988) wrote (p. 169):

> Chagall's great gift is literally the power of imagination, the ability to summon and exteriorize on canvas, or other mediums, the substance of dreams, the intangible mirages of the mind.
>
> ... Part of the secret power of Chagall's art is in the artist's struggle against all the forces that shackle the flight of inspiration and pull man downward. The soaring, floating, running, jumping images in his paintings are symbols of liberation.

Fantasy is creative, enabling us to experience new and meaningful totalities. The gift of fantasy varies considerably from one person to another. Some people claim to lack any fantasy at all, but no one is ever wholly without some fantasy. In children, the borderline between fantasy and reality may be very diffuse. A child may be completely convinced that she or he saw a real lion in a closet or a real tiger strolling in the garden. Such a child is not consciously lying.

Qualls and Sheenan (1983) argued that fantasy has a critical, but frequently unrecognized, part to play within the present educational system. They showed that make-believe play in children could contribute to the cognitive, emotional and social development of the children. Qualls and Sheenan stressed the need to encourage fantasy in children if the imaginable capacities of fantasy are to survive into adult-hood. There is a clear need to design educational experiences to stimulate imaginable modes of thinking.

Our present educational system definitely favours verbal, logical (left hemisphere) modes of thinking. Encouragement is needed for the individual child to use both verbal and visual modes of thinking, to be capable of both convergent and divergent thinking, and to be both rational and intuitive. Fantasies can include visual but auditory, tactile, and other sensory experiences. Fantasy is a basic component in our culture. It can be expressed in numerous ways, i.e., in artistic, scientific, and practical creativity, games, illusions, daydreams, and (sleep) dreams. Hallucinations are an extreme form of fantasy.

Self-images

A self-image or ego image is the view a person has of her-/himself on a particular occasion. This view usually differs in many respects from the view held by other people. A person may regard her-/himself as rather fat (self-image), prefer being slim (target image) but actually have a normal build (objective image). Self-confidence is a measure of how positively we view ourselves.

Closely knit groups, such as a football team, a teenage gang, a religious sect, or a political extremist group, may strive to create a very considerable common identity. Common views and values, similar actions, clothing, uniforms, hairstyles, badges, symbols, etc., enhance the feeling of affiliation. Group members often acquire a definite “collective self-image.” Companies, public agencies, and different kinds of clubs always have some kind of collective self-image. Employees, members, and supporters usually have a “we” outlook, i.e., some shared perception of the organization’s identity.

Richardson (1983:30) concluded that people who have the ability to form and control vivid memory images are more successful in influencing their own mood states and are more likely to benefit from the mental practice of perceptual motor skills. Richardson suggests that those who suffer from weak memory imagery can be helped to make it more vivid with all the potential advantages that this has for utilizing a greater number of self-management skills.

Target images

A target image is the image a person forms about her/his future in life. Dreams, visions, hopes, or fears are decisive to a person’s involvement in preparations for her/his future. Ingvar (1975) noted that our perception of the future is highly important to us (p. 56, in translation): “The memories we have, our experiences, the knowledge we acquire in life, are governed by the vision we have of the future.” A positive target image is the ideal image (“ego ideal”) people form about themselves, their goals for personal development, i.e., things they would like to become and actively strive to achieve. For example, politicians often see themselves as victors in a future election. Many successful athletes see themselves as winners on top of the winner's stand. They repeatedly perform mental "dry runs" of a future contest/game, polishing their imagined performance each time. This kind of "mental training" may be as demanding and strenuous as real physical training. The area of target images has attracted a large number of authors to produce a never-ending number of tests, articles, and even books on "self improvement".

Dreams

The Longman Dictionary of Contemporary English (Longman, 1990) as well as The Oxford Dictionary and Thesaurus (Tulloch, 1995) provides five definitions of the concept dream. The Random House Dictionary of the English Language (Berg Flexner, 1987) has 14 definitions of the concepts dream, dreamed or dreamt, dreaming. Basically a dream is an experience of a series of images and ideas that occur during our sleep. Carlson (1993) pointed out that sleep is behaviour, not just an altered state of consciousness. Although dream experiences are imagery, they seem very real. Some dreams are pleasant; others are annoying or even frightening.

Dreams and dreaming are studied from a traditional psychoanalytical approach, and also from a physiological viewpoint. Dreaming is a distinct, natural and necessary part of sleeping, usually characterized by the occurrence of rapid eye movements, REM (Carlson, 1993). Everyone dreams four to six times a night. Each dream will last from 15 to 20 minutes. The study of dream content is limited. Because most or our dreams are very soon forgotten we often believe that we have not dreamed at all. The majority of dreams seem to reflect happenings, thoughts, and feelings of the previous day or days. Sometimes, people dream about things that they avoid thinking about while awake, and these dreams may be filled with symbols whose significance they cannot recognize. Dream content seems to be a dynamic mixture derived from current stimuli, past experiences, interests, and urges. Although dreams apparently occur in colour, they often fade to black and white in memory.

Subliminal reception

In 1957 an advertising expert claimed that he had inserted subliminal visual messages in a showing of Picnic, a popular film (Carlson, 1993). The messages, which said “Eat Popcorn” and “Drink Coke,” supposedly caused people to rush to the refreshment stand and purchase these items. This story received much attention and a lot of publicity, and it is often cited in the literature. However, several years later, the advertising expert admitted that he had invented the whole story in order to get favourable publicity for his advertising business. No subliminal visual messages were used and no customers rushed out to buy popcorn and Coke.

According to Dudley (1987), subliminal reception may be defined as the individual’s ability to perceive and respond to stimuli that are below the “limen” or level of consciousness. Above it stimuli are called supraliminal. Dudley outlines four methods of subliminal stimulation:

1. A tachistoscope that flashes messages or pictures so rapidly that the viewer is unaware of their presence.
2. Accelerated speech in low volume auditory messages.
3. Embedding or hiding pictures or words in larger pictures or ornamental detail.
4. Suggestiveness, the image implying quite a bit more than a quick glance would indicate.

Sutton (1990) provided an extensive overview of research on subliminal reception. He concluded (p. 12), “In summary, it seems apparent that the phenomenon of subliminal reception is a scientifically demonstrated phenomenon. It is also apparent that there needs to be precise definition of what we mean when we use the term. It is equally clear that much of what is being claimed commercially as subliminal effects is not scientifically validated through carefully controlled independent testing and experimental replication. The reaction of the media to the phenomenon is often lacking in awareness of the problem and its history. Government forces, while wary of the hidden dimension involved, seem unable and unfitted to deal with the situation. In some areas the media educator and visual literacy practitioner have little role to play beyond being a concerned citizen and consumer but in others, especially in the area of ad design and appeal on the basis of meaning through inference and implication, there is a great need for media awareness and visual literacy”.

Memory models

Our memories make it possible to store experiences, recognize things, and learn. With the help of our memories we can think and tackle the problems that face us. Memories give us a place in the time dimension. Memories become a part of our personalities. However, whether memory is a basic source of knowledge or not is a controversial issue. According to Bernecker (2015) some philosophers maintain that memory only retains or preserves knowledge but doesn't produce new knowledge. Others insist that there are cases where a person first comes to know by remembering.

Linsday and Norman (1977) stated that in the teaching-learning environment, "the problem in learning new information is not getting information into memory; it is making sure that it will be found later when it is needed" (p. 337).

A number of models or theories describe the transfer of information through memory (Atkinson & Shiffrin, 1968; Broadbent, 1984; Lockhart & Craik, 1990; Norman & Bobrow, 1975; Sinatra, 1986; Waugh & Norman, 1965).

One thing that is common to all the phases of the analysis performed on incoming information is the need to store the signals for varying lengths of time, so that the information processing can be carried out. In psychological terms, the processes that carry out this information storage are referred to as "memories."

One way of viewing memory functions is based on information processing in steps (Atkinson and Shiffrin, 1968), the "*information processing theory*." On the basis of the length of time that memories last, Bloom et al. (1985) noted that there are three kinds of memories: 1) immediate memory, 2) short-term memory, and 3) long-term memory. However, according to Moore, Burton & Myers (2004) the information-processing model suggests that we have several memories governed by processes that convert stimuli to information.

Immediate memory

The first of these steps is the *immediate memory*, or the *sensory memory*, which carries out the storage of stimulus information at the peripheral level.

Loftus, Shimamura, and Johnson (1985) showed that for one tenth of a second as much information can be extracted from this sensory memory icon as from the picture itself. The *echoic memory* (hearing) and the *iconic memory* (vision) are closely related to the sensory memory. These memories precede the integration of signals from various sensory systems. The function of the sensory memory appears to be to hold onto information long enough for it to be transferred to the next form, the short-term memory.

Hearing a sentence, a word, or even a syllable requires the listener to integrate a changing pattern of auditory stimulation. This integration demands some form of short, temporary buffer storage, and it is likely that perception relies heavily on such temporary memory stores that holds a representation of the initial sounds until the entire word has been heard.

Sweller (2005) defined sensory memory as the cognitive structure that permits us to perceive new information. Sensory memory holds an exact sensory copy of what was presented for less than one quarter of a second (Mayer 2010).

According to Mayer (2005b) we have a visual and an auditory sensory memory. The visual sensory memory briefly holds pictures and printed text as visual images. The auditory sensory memory briefly holds spoken words and sounds as auditory images.

Another example of the immediate memory is the biochemical processes in the eye. The visual cells there possess some inertia and, therefore, function as a kind of memory. The immediate memory normally stores information for half a second to one second.

Short-term memory

Atkinson and Shiffrin (1968) presented a *short-term memory model*. It was a structure for temporarily storing information before it passed to long-term memory. Baddeley and Hitch

(1974) proposed a more complex model, which they called working memory.

Miller's (1968) initial review of short-term memory research related to items like brightness, colour, digits, hue, length, letters, loudness, pitch, size, and taste. Most people can repeat a seven, or eight, digit telephone number, but not ten or eleven digits. Subsequent studies have come to similar conclusions (Bazeli and Bazeli, 1992; Case, 1974, 1975; Pascual-Leone and Smith, 1969). In teaching it is important not to overload students with too much information (Cook, 2006).

After being processed in the iconic memory and the echoic memory, some information is passed on to the *short-term memory* (STM), *operative memory*, or *working memory*, where it is only retained briefly, not more than one to two seconds. A number of complex operations are carried out here during problem solving. But the short-term memory has severe capacity limitations. It is limited in storage capacity.

The short-term memory has several subsystems or components to deal with different types of information: a verbal or phonological component, an active component, and a passive component (Hitch, Woodin and Baker, 1989).

Reading texts and pictures, and active listening, depend on our short-term memory, as does all mental activity. Only a certain limited amount of information can be contained in the short-term memory at any one time. New information replaces information that is older than about a second, and the older information easily disappears if we are not prepared to store it in our long-term memory. If we repeat the information a few times, we increase our chances of remembering it. Long, complex words and sentences are difficult to understand. If the functions of the individual words in a text are not immediately apparent to us, our short-term memory becomes overloaded with long chains of words that cannot be directly put into a meaningful context.

Information that has entered the short-term memory can proceed through a filter that selects the information to be passed on to the long-term memory. Once this filtration has taken place and certain information units have been assigned priority over others, these priority units are given access to a "register" with a limited memory capacity. This is when a person becomes aware of the stored information. All other non-priority information disappears, normally forever if it is not re-transmitted to the filter when the filter is able to accept the traffic. The filter scrutinizes the information received from the outside world and identifies the specific properties of this information. When the information involves aural signals, the filter notes whether the signal is strong or weak. When visual signals are involved, the signal is scrutinized for information on for example colour, size, direction, and movement.

Learners generally use rehearsal strategies to facilitate cognitive processing of new information. Without such processing there is no later storage. According to Weinstein and Mayer (1986), rehearsal strategies are designed to repeat information while it is in the short-term memory to compensate for the time and limitations there. The longer an individual can rehearse information, take notes, analyse and interact with texts and visuals in an active way, the greater is the possibility that this information will be moved from the short-term memory to the long term memory and that increase in retention will occur (Murray and Mosberg, 1982).

Sweller (2005) defined working memory as the cognitive structure in which we consciously process information. Our working memory selects information from our sensory memory for processing and integration. Generally working memory holds the processed version for less than thirty seconds (Mayer 2010). Working memory can only process a few pieces of material at any one time.

Long-term memory

The long-term memory is what most people mean when they refer to "memory" (Carlson, 1993). The long-term memory has *episodic memories* of specific things we have done, seen, heard, felt, tasted, and so on. They are tied to specific contexts. Semantic memories consist of conceptual information such as our knowledge of the names of birds and flowers. The information that passes the "register" can proceed in different ways. The information can be stored in a long-term memory (LTM). This is what normally happens with the knowledge we do not need for the moment. This long-term memory then sets the rules for the selection filter, so that the filter makes selections related to previous experience (see Levie, 1987; Sinatra, 1986; for reviews). To facilitate these processes the information designer should organise information carefully.

Information is processed and remembered in chunks that are organized hierarchically. We have to think about and work with new information in order to get it into our long-term memory. Learning requires brainwork. The more often a message is sent, the more familiar it becomes and the more likely it is to be remembered. This is basis for a much of the advertising.

According to Carlson (1993) long-term memory appears to consist of physical changes in the brain — probably within the sensory and motor association cortexes. In daily life it is easier to recall general concepts than specific events. To some extent this is due to the fact that the former usually constitute an integrated part of larger mental networks, whereas the latter more often have a fragmentary, non-connected status (Waldahl, 1998). In part this is because general concepts have larger number of mental cues pointing to them from different positions.

According to Branch and Bloom (1995) visual information is usually retained longer in memory than verbal information. The short-term and long-term memories are actually theoretical models that cannot be related to any activity pattern or any particular anatomical structure in the human brain. The distinction made between the STM and LTM is probably too clear-cut. Information can also be passed on to an "output system," which emits signals to the muscles that are to carry out a given act. The information can be switched back from the "register" to the reception or to the short-term memory.

Beaver (1994) claimed that visual memory is very fast. It is one thousand times faster to view an inner image than to rehearse a word from verbal memory. In accordance with Kosslyn (1975), more details of a mental image of an object are remembered when the object is imagined next to a smaller object. Thus, the relative size of a part of an image may affect our ability to remember and recognize it.

Sweller (2005) defined long-term memory as the cognitive structure that stores our knowledge base. Our long-term memory holds a person's knowledge for an indefinite amount of time (Mayer 2010).

Conceptual change theory

Concepts are mental representations corresponding to words. For example, the concept "tree" is a mental structure that corresponds to the word "tree" and refers to trees in the world.

Concepts may also represent a set of ideas that can be described by a few words. Several concepts can act as building blocks of more complex or even abstract representations.

The terms “conceptual change,” “conceptual change model” (CCM), and “conceptual change theory” can be seen as the mental processes that alter our understandings of concepts, as well as the relationships between them, in content and organization. Initially the idea of conceptual change was used in education as a way of thinking about the learning, and re-learning, of changing meanings of important concepts in disciplines such as physics (Posner et al., 1982) and biology (Carey, 1985).

Hewson (1981, 1982) expanded the idea of conceptual change from physics and biology to other disciplines. Today the study of conceptual change is an interdisciplinary field. It is often discussed in teaching of science and technology. In these disciplines students cannot rely on simple memorization of facts in order to understand advanced concepts. Here students must learn to restructure their intuitive knowledge based on culture and experience.

Because conceptual change is needed teachers must find ways to enhance the motivation of individual students. According to Jonassen (2006) conceptual change is the mechanism underlying meaningful learning. According to diSessa (2008) the central principle of conceptual change research is the constructivist idea that old ideas (or mental structures) are influential in supporting or constraining learning (or development).

Since the mental construction processes are influenced by a variety of social experiences, Hewson (1992) argued that knowledge constructed by each individual is not normally completely idiosyncratic and personal. Existing knowledge and cultural and social agreements about meaning not only limit how new experiences are interpreted, but also influence what is perceived in any situation. Thus, two individuals exposed to the same events may perceive and interpret them in very different ways. This depends on their individual underlying beliefs and knowledge, and the ways in which these beliefs influence and are influenced by the social interactions out of which they are formed.

Özdemir and Clark (2007) concluded that a body of conceptual change researchers have made significant progress on two competing theoretical perspectives regarding knowledge structure coherence: 1) knowledge-as-theory perspectives, and 2) knowledge-as-elements perspectives.

These two perspectives implicate radically different Conceptual change through "knowledge-as-theory" was derived from the work of Piaget's learning theory and Kuhn's concept of normal science and scientific revolution. This perspective was summarized in the following question: "Is a student's knowledge most accurately represented as a coherent unified framework of theory-like character?"

Conceptual change through "knowledge-as-elements" recognizes a student's understanding of material through their interaction with the world. This perspective was summarized in the following question: "Is a student's knowledge more aptly considered as an ecology of quasi-independent elements?"

There are significant similarities and differences between knowledge-as-theory and knowledge-as-elements perspectives. If a learner's understanding is theory-like, and if certain specific conditions are met, the learner will become dissatisfied with existing conceptions when conflicting examples are introduced to the learner. If a learner's intuitive knowledge is elemental in nature, instruction should focus on how those elements are activated in appropriate contexts. From a constructivist view, all of the various elements in a student's conceptual network are subject to progressive knowledge construction.

Vosniadou (2007) proposed a conceptual change model for iconic and symbolic visual representations existing in a learner's schema structures. Here mental representations are hold together in an organized fashion. This allows people to understand how different pieces may be related, and how they may influence each other. The "Vosniadou conceptual change model" has five interconnected key components in a three-dimensional structure. These components are 1) framework theories, 2) presuppositions, 3) conceptual domains, 4) concepts, and 5) specific theories.

According to the *framework theories* already existing knowledge will influences how a learner may understand new information. Visual data may be used in science instruction and learning. Framework theories are large overarching sets of knowledge. These structures frame learner understanding and serve the learner as lenses through which he/she "sees" knowledge (Finson & Pedersen, 2015).

At any single instant, a learner may hold multiple framework theories. A learner's framework theories include his/her intuitive knowledge, knowledge gained from life experiences, and beliefs. The learner presumes that some information is accurate, and applicable to the situation. *Presuppositions* act as filters for the transfer of information into schemata, and may therefore effectively hinder alternative explanations. Examples of presuppositions: 1) Visual data may be used as effective tools. 2) Visual data are limited and cannot be used in all learning contexts.

A *conceptual domain* is a coherent body of knowledge. The learner may use knowledge from several different domains. A conceptual domain will include many concepts. Conceptual domains may concern the function of the brain and the cognitive building of schemas.

A *concept* is a small piece of subject matter knowledge. Several related pieces are used together as *units*. Examples of concepts are visual perception, visual learning, and visual thinking.

Sets of interrelated propositions form specific theories. *Specific theories* are influenced by attitudes, cultural contexts, social contexts, and motivations. Examples of specific theories concern various aspects of areas such as cognition, learning, and visual literacy.

This framework may guide science educators in making more effective use of "visual data" in instructional contexts. Vosniadou defined *visual data* as visual inputs beyond visual information.

Other memory models

On the basis of the functions that memories perform they seem to be either (a) procedural, or (b) declarative (Pines, 1986).

Procedural memory, or *implicit memory*, is a kind of memory for skills that we perform in an automatic and unconscious way. Here our previous experiences aid our performances. This unconscious memory is capable of controlling rather complex behaviours in our daily lives. Procedural memory allows people to remember how to get dressed in the morning and prepare breakfast without consciously thinking about all the details related to these activities. Procedural memory probably develops earlier in life than declarative memory.

Declarative memory, or *explicit memory*, is a conscious memory. It is the memory of which we are aware. We remember previous experiences, facts, and information, and we can recollect what happened years ago. We know that we have learned something, and we can discuss this with others-

Comparisons are sometimes made between the human brain and a serial computer. However, the brain differs in many ways from a computer. As a rule, a computer must be able to process considerably more information than a human in any given situation, since most computer programs are unable to distinguish between important and unimportant information. Usually the machine is therefore incapable of ignoring any information in the way that the human brain constantly does. This is one of the reasons why a person's ability to process sensory information is far beyond the capability of even giant computers, even though the individual processing steps are carried out much faster in a computer than in the human brain, about one million times faster. A major difference between the human brain and serial computers is that damage to serial computers is disastrous. If parts of the central processor or memory elements are destroyed the whole system "crashes." However, moderate damage to the human brain only reduces its efficiency.

Drew and Grimes (1985) studied the process of learning from television news and the relationship between audio and visual channels. The results from the study showed that close coordination between audio and video improved audio recall of television news stories, and redundancy aided story understanding and audio information recall.

In conclusion, results from several experiments show that learning is maximized when the contents are the same in, audio, print, and visual channels. The content, the context, the format, and the structure of a visual influence the viewer's ability to perceive its message.

Forgetting

Forgetting is the process through which information in memory becomes inaccessible, either because the information is no longer stored or because it is stored but is not at that time retrievable. Forgetting is rapid at first and then gradually levels off. This process may be increased by interference from other material, either learned beforehand or subsequently. The amount of forgetting increases with the amount of interfering material and with its similarity to the material being remembered. People tend to remember what they regard as most important; they typically operate by attempting to reconstruct the incident using their existing knowledge, with the result that they may recall what would have been expected instead of what actually occurred.

A number of techniques are available for improving memory. Buzan (1977) discussed specific memory systems that establish links between or exaggerate the image of things to be recalled. The mere act of making a special effort to remember may suffice to improve memory capacity. Mnemonics are additional cues to help retrieve the appropriate information. For example, a mnemonic for remembering the order of the colours of the spectrum, red, orange, yellow, green, blue, indigo, and violet, uses the sentence "Richard of York gains battles in vain." The colour names are first reduced to their initial letter, and these are then elaborated into a meaningful sentence, providing a sequential organization not present in the order of the colour names themselves.

Several researchers have reported that large amounts of text are more likely to be forgotten than small amounts of text (Bradshaw, 2000).

Intellectual development

The ability of children to decipher the contents of a picture is governed by their mental development, previous experience, and social circumstances.

Increasing capacity

According to Piaget's *Cognitive development theory* (1926, 1936) chronological age is the most important factor in a child's mental development. Piaget described four stages of that development:

1. The sensory-motor period (0–2 years).
2. The pre-operational period (2–6/7 years).
3. The period of concrete thought processes (6/7–11/12 years).
4. The period of formal or abstract though processes (from 11/12 years to about 15).

The child gradually develops internal cognitive schemas that strengthen synapses in the brain.

Miller's (1956) initial review of short-term memory research, "The magical number seven, plus or minus two: Some limits on our capacity for processing information," related to items like brightness, colour, digits, hue, length, letters, loudness, pitch, size, and taste. Subsequent studies by Case (1974, 1975), Pascual-Leone and Smith (1969), and Bazeli and Bazeli (1992) have come to similar conclusions. They also found clear differences over age groups with children having an increasing capacity until reaching adult levels in the middle teen years. Bazeli and Bazeli (1992) provide rules of thumb for this increasing capacity (p. 44).

> As a rule of thumb second graders ought not be asked to handle new information that contains more than two or three steps or components at one time, fourth graders no more than three or four, seventh graders no more than four or five, and high school students no more than five or six. Presentations of new information ought to include combinations of visual and verbal media, but teachers should be careful to limit simultaneous multi-media presentation of information they appear to be more distracting than helpful to some students.

Results indicate that visual language abilities develop prior to and serve as the foundation of, verbal language development, at least for three-, five-, eight-, and twelve-year-olds (Reynolds-Myers, 1985; Moriarty, 1994). These languages are apparently more efficient than verbal languages in memory tasks. A verbal response to a visual stimuli or a visual response to a verbal stimuli requires a transformation from one modality to another. (See the section *Modalities*.) The ability to transform from verbal to visual modality develops more rapidly than the transformation from visual to verbal modality. Development of visual language abilities is dependent upon receiver interaction with images, objects, and also body language (Fleming & Levie, 1978, 1993; Reynolds-Myers, 1985).

We may have one kind of memory for pictorial material and another for linguistic material. Pictorial stimuli are stored as images and not as words. The stimuli cannot be recalled without extensive cognitive efforts to retrieve the stored image, transform it into words and then verbalize those words.

Pupils in junior schools (Backman, Berg, & Sigurdson, 1988; Eklund, 1990) have very low "pictorial capability." The same is true for pupils in intermediate schools, junior high schools, and in comprehensive schools (Backman, Berg, & Sigurdson, 1988). In addition comprehensive school students are poor at expressing themselves with pictures (Backman, Berg & Sigurdson, 1988; Eklund, 1990). Furthermore, inconsistent use of graphics in information and learning materials is quite common. This will reduce understanding and learning (Bradshaw, 1996, 2003).

Reynolds-Myers (1985) suggests that we put the theories of Piaget (1968), Bloom (Bloom et al., 1956), and Gagné (Gagné & Briggs, 1974) together to be able to meet the principles of visual literacy. Basic assumptions of Piaget's theory:

1. The ability to think and reason occurs in developmental stages through which individuals progress in an invariant order.
2. These stages are dependent upon several interacting factors: physical maturation, experience, social transmission, and equilibration.
3. Although the stages develop in a fixed order, individuals move from one stage to another at different ages.
4. An individual may function in one stage for some bodies of knowledge, while he functions in a different stage for other bodies of knowledge.

Basic assumptions of Bloom and Gagné:

1. Desired learning outcomes can be described and classified into levels of learning.
2. A higher class of learning subsumes all lower levels of learning.

3. Instruction can be designed to allow the learner to develop the desired level of learning.
4. However, before we can do this we must refine the means of testing for learning. At the present time, most learning is measured or assessed through verbal means.

TV and movie comprehension

Noble (1975) analysed the way in which children of different ages perceive the content of TV programs and found very wide differences between children in the different stages of development. Children from 2 to 6 tended to either strongly like or dislike what they saw. They had difficulty in distinguishing between internal and external experiences, i.e., between imagination and reality, and felt involved in and able to influence events in TV programs. They are unable to comprehend how different aspects of an event may be interrelated and therefore view TV programs as a succession of mutually unrelated happenings.

When children acquire the ability to carry out reversible thought processes in the third stage of their development, they begin to respond systematically to concrete stimuli in their surroundings. Their world of thought is no longer restricted to the present, and it becomes possible for them to foresee events and understand relationships. At the beginning of this stage of development, the children concentrate on special events in a TV program, but they gradually begin to understand the plot.

Children from 11–12 are only capable of understanding the concrete, physical behaviour of the TV performers, not the emotions supplying the motivation for a given action. From about the age of 13, children begin to be capable of dealing with logical thought processes on an abstract plane. Only at this stage do they acquire the ability to understand the indirect symbolism often found in movies and TV programs.

Noble found that TV producers could accurately predict what children would like, but not what children would understand. Social circumstances, in addition to chronological age and intelligence, play an increasingly important role in the ability of children to understand the events in a TV program. Various studies have shown that middle-class mothers talked and discussed things with their children to a greater extent than working class mothers. In Noble's view, therefore, we can expect to find similar differences regarding TV programs. The socialization process in middle-class children means that these children tended to receive more encouragement in understanding the programs.

Tröger (1963) felt that children first have to learn to comprehend individual pictures before they can comprehend the plot of a movie. A basic requirement here is that the children really are capable of distinguishing between an object and a picture of that object. Only after this is possible is a child mature enough to deal with various subjects on an abstract level. Tröger suggested that children do not achieve picture comprehension until they reach the age of about six. Comprehension of movies is therefore only possible after this age. Tröger defined the following stages in movie comprehension:

1. The child attains picture comprehension, i.e., the ability to distinguish between an object and a picture of the object.
2. The child comprehends individual scenes in a movie. But these scenes are not perceived as being related to prior and subsequent scenes.

3. The child begins to comprehend the interrelationship of individual scenes.
4. The child begins to comprehend all the relationships in the film.

Tröger's view is in close agreement with Piaget's and Noble's with the exception of age level. Actually, children probably attain facility in picture comprehension at a much earlier age than six, possibly as early as three years. In Tröger's view, children under seven perceive movie reality differently than adults. Even here Tröger described four stages of development which arise in chronological order but at different ages for different children, depending on their development in other respects:

1. The child lacks movie comprehension and views a movie realistically.
2. The child views a movie as a reproduction of reality, i.e., the events on the screen have really happened. The photographer just happened to be passing and made the movie.
3. The child perceives the movie as possible reality, i.e., they understand that the movie was made but that the events in the movie could actually happen in reality.
4. The child perceives the movie as selected and processed reality. Not every adult reaches this stage.

In the United States, TV programs made for children are basically designed in the same way as programs for adults. In programs such as Sesame Street, for example, children see a series of rapid and varied scenes that are frequently unrelated to one another. Children's programs in Sweden are better tailored to children's prerequisites.

The former Soviet Union was even more advanced in this respect. The state-run Soviet TV company produced programs for five age groups: up to the age of 7, 8–10, 11–14, 15–18 and over 18 years of age. The former Eastern Bloc countries have amassed considerable know-how about the way TV programs should be designed to suit different age groups. However, less is known about this subject in the West.

Understanding advertising

According to Barry (1998) magnetic resonance imaging scans lend insight into how children and adolescent brains process incoming messages and differ from adult brains in ascribing meaning to visual messages. Adolescent brains, for example, appear to process emotions primarily in the area of the amygdala, a cluster of nerve cells in the depth of the temporal lobe. As they mature, brain activity shifts toward the frontal lobe, where rational processing takes place. This allows adults to respond to emotional stimulation with reason, and to put "rational brakes" on peripheral cues such as colour and imagery.

Children and adolescents, however, have less information-processing ability. They do not pay attention to factual information in advertising and do not process advertising through logical assessment and rational analysis. Children and adolescents tend to ascribe meaning to peripheral cues such as colour and imagery and process advertising through their emotional associations. The same visuals are not equally effective for receivers with different prior knowledge.

This means that advertising based on factual attributes such as price, ingredients or product features is likely to appeal to adults. Advertising based on images is likely to appeal to both adults and children, but children lack the rational development through experience that would put rational brakes on the ad's effects. This is why ads which suggest the types of people who might use a specific product, and use cues to tap into emotionally loaded experiences with which children can identify – in reality or in fantasy – are particularly effective on children. Visual messages with carefully crafted emotional appeals bypass logic.

Basic geometric shapes

When a person attempts to copy a drawing made by someone else, he or she generally simplifies the subject so that it increasingly assumes simple, basic geometric shapes such as circles, rectangles, and triangles. When small children begin to make pictures of their own, the circle is generally their first definable area, followed by the square and then the triangle. The external contours of an image and its "total shape" are probably very important to the way we perceive image content.

My own study of the image creativity of children (Pettersson, 1979) showed, among other things, that the paper's edges, the corners in particular, attracted the children's attention. They pointed out that one of the most striking things about a photocopy is its rectangular shape and its white frame. These properties may very well have an effect on and interfere with our perception of the image subject itself. This influence was apparent in one-third of the pictures made by children from two to seven.

Yarbus (1967) and many other scientists have shown that we only fix our attention on certain elements of a picture's image, so it is possible that the corners of rectangular and square pictures are distracting to small children reading a picture. The corners may demand attention that should be conferred on image content. An ideal picture should probably be oval with blurred edges i.e., the image should emerge from the background, about the way Gibson (1966) described our perception of "selected visual fields." Pictures in our books and newspapers have not always been rectangular and square, and we can find interesting differences in different cultures. Today, we live in an age increasingly dominated by television. Children may ultimately expect all images to have the same format as a TV screen.

According to Goldsmith (1987) most children, in cultures where pictures are a regular feature of the environment, are "pictorially literate" by the time they are about eight or nine. However, Barufaldi and Dietz (1975) found that most of the children between grades one and six performed better in observation and comparison tests when using real, solid objects as opposed to pictures of the same objects.

Details of a picture

Amen (1941), Mackworth and Bruner (1970), and a number of other authors have commented on the tendency of young children to become absorbed in details of a picture at the expense of the whole. Elkind, Koegler, and Go (1964) found that children are generally unable to switch attention voluntarily from parts to whole until they are about nine years old. Barry (1998) noted that 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. Because of this, persuasion tends to be accomplished in both children and adolescents almost exclusively through imagery.

Illustrations in materials for use with children under thirteen should be strictly relevant to the text. Younger children cannot ignore incidental illustrations. If pictures do not help, they will probably hinder the understanding of the content.

Processing theories

Mental processing is a designation for the mental processes in which we process information into knowledge with reference to our earlier experiences and memories. The information must be internalized and made our property, as part of our memory.

Mental application is a designation for the mental processes in which we make use of our new knowledge and test it in for confirmation. We will remember relevant and meaningful information if we have use for it. Hereby, knowledge is internalized and can influence new attention.

In this context this field of knowledge includes four areas of knowledge: 1) schema theory, 2) constructivist learning theory, 3) action theory, and 4) dual coding theory.

Schema theory

The British psychologist Frederic Bartlett (1932) used *schemata* (or *schemas*) as a basic concept when he developed his learning theory. Barlett suggested that a network of abstract *mental structures* form our understanding of the world. In Piaget's theory of development, children adopt a series of schemata to understand the world. A schema is a unit of understanding stored and organized in the long-term memory. A schema contains general expectations and knowledge about events, people, places, and social roles (Rumelhart, 1981; Sinatra, 1986). In cognitive science and psychology, a schema describes an *organized pattern* of behaviour or thought. A *schema* is a cognitive framework or concept that helps organize categories of information and the relationships among them. We use genres, prototypes and our *mental schemata* in communication (Bondebjerg, 1994; Höijer, 1992a, 1992b).

Schema theory describes how knowledge is acquired, processed and organized. The focus is on how we assign meaning to things through social experience (Davis, 2012, p. 80). We use schemata to organize current knowledge and provide a framework for future understanding. We are more likely to notice things that fit into our already existing schemata. Our schemata are constantly refreshed and restructured through new knowledge, while additional connections among related schemata are made. We build new concepts on the foundation of older ones. However, schemata can also contribute to stereotypes and make it difficult to retain new information that does not conform to our established ideas about the world.

For competencies to be acquired, it is essential that the learner brings the important elements of knowledge required by the task. These elements of knowledge consist of concepts, propositions, episodes, production rules, procedures, or heuristics. New concepts are built on the foundation of older ones, and new propositions are formed with concepts already possessed by the learner. Processing of this kind is essential for experience, understanding, and expectations.

According to Taylor and Crocker (1981) there are four types of mental schemas or schemata: 1) person schemas, 2) role schemas, 3) event schemas, and 4) self-schemas. Person schemas organise our knowledge of persons. Today media is our most important source of information of persons and groups of which we have no direct knowledge. Role schemas organise our expectations in persons with particular roles and positions in society, and their behaviour in different situations. Event schemas organise our conception of the content, and of the sequences of events. Self-schemas organise our considerations of ourselves as persons. The image of the self is important to us. People's mental schemas are continuously developing, and every day we meet reality with a somewhat different view than the day before.

In accordance with Bruner (1966), we use three systems to form models of reality: 1) actions (Enactiv), 2) pictures (Iconic), and 3) symbols (Symbolic or Abstract). Instruction that is provided to a learner should proceed from direct experience (as in demonstrations, field trips, and exhibits), through representations (as in signs and words). The sequence in which a learner encounters materials has a direct effect on achievement of the mastery of the task. By operating and manipulating objects we get experiences. Pictures provide us with a holistic view. Using symbols makes it possible to handle abstract ideas and thoughts. Language is the main tool for abstract thinking.

A memory is a mental image enabling us to visualize an object, event, or a particular situation. In some way, we retrieve and "activate" a copy of this visualization stored in our long-term memory. Many people have described the "near-death experiences" they had just before losing consciousness. These experiences often encompass a large number of wide-ranging images of events throughout their lives, flashing past in a rapid, sometimes chaotic, succession. They may even recall people, places, and events from their earliest years. Buzan (1977) suggested that people in this situation may well remember everything that has ever happened to them. Normally, we are unable to access all information stored in our long-term memory.

Strömquist (1991) pointed out that we all have proficiency in, and insight into, the labours of writing. We all know how writing is done. We know that "the writing process" consists of more than simply committing words to paper; indeed, it presupposes long-term memory and familiarity with the things that have to do with writing. In other words, writing is an extensive, time-consuming, dynamic, gradual, cognitive, and strenuous business. The schemata that we use when we read influence our deeper understanding of the content in the text Gunnarsson (1982). The reading procedure is of great importance to our capacity for understanding.

Understanding and long-term memory are closely connected. It is unlikely that someone would understand a concept without drawing from stores of information accessible by long-term memory (Brown and Bookman, 1997).

Constructivist learning theory

According to the active processing assumption, and Mayer's *constructivist learning theory,* people construct knowledge in meaningful ways when they pay attention to the relevant material, organize it into a coherent mental structure, and integrate it with their prior knowledge (Mayer, 1996, 1997, 1999).

Mayer (2009) has called such meaningful learning for the *science of learning*. *Science of instruction* is defined as the "creation of evidence-based principles for helping people learn" (Mayer, 2009, p. 29).

The *cognitive theory of multimedia learning* has the following components: 1) a dual-channel structure of auditory and visual channels, 2) limited processing capacity in memory, 3) sensory memory, working memory, and long-term memory, 4) five cognitive processes (selecting words, selecting images, organizing words, organizing images, and integrating new knowledge with prior knowledge), 5) theory-grounded and evidence-based multimedia instructional methods.

According to Mayer (2005b) there are five kinds of representations. The first representation consists of the pictures and the words in the actual multimedia presentation itself.

The second representation consists of the mental representations for sounds and images in our sensory memory. The third representation consists of the mental representations for sounds and images in our working memory. There are also verbal and pictorial models, the fourth form of representation, in the working memory. The fifth representation consists of our prior knowledge, stored in our long-term memory.

Moreno and Mayer (2000) presented six *instructional design* principles for this theory:

- *Split-attention principle*: Students learn better when the instructional material does not require them to split their attention between multiple sources of mutually referring information.
- *Modality principle*: Students learn better when the verbal information is presented auditorily as speech than visually as on-screen text both for concurrent and sequential presentations.
- *Redundancy principle*: Students learn better from animation and narration than from animation, narration, and text if the visual information is presented simultaneously to the verbal information.
- *Spatial contiguity principle*: Students learn better when on-screen text and visual materials are physically integrated rather than separated.

- *Temporal contiguity principle*: Students learn better when verbal and visual materials are temporally synchronized rather than separated in time.
- *Coherence principle*: Students learn better when extraneous material is excluded rather than included in multimedia explanations.

Moreno and Mayer (2000) concluded that presenting a verbal explanation of how a system works with an animation does not insure that students will understand the explanation unless research-based principles are applied to the design. Multimedia presentations should not contain too much extraneous information in the form of sounds or words.

However, according to Koumi (2013, p. 102) the cognitive theory of multimedia learning with its six principles exemplify the mismatch between the research literature and the concerns of practitioners who are actually producing multimedia packages. The principles are too all embracing. For example the split-attention effect leads to the either/or recommendation that audio text is always superior to screen text.

According to Koumi (2013, p. 89): "UK Open University multimedia packages are typically produced over several script conferences by a team of experienced teachers who know their target audience well." Over time such a team develops a *tacit, intuitive design model*. In his article Koumi: "seeks to pull together these tacit design models and make them explicit." He offered forty detailed, usable micro-level, design guidelines for design of pedagogic harmony between spoken commentary (oral text), visual texts (text displayed on the screen), and images in multimedia packages.

Based on results from nearly one hundred studies Mayer (2009) identified twelve multimedia *instructional principles*:

- *Coherence principle*. People learn better when extraneous material is excluded rather than included.
- *Signaling principle*. People learn better when cues that highlight the organization of the essential material are added.
- *Redundancy principle*. People learn better from graphics and narration than from graphics, narration, and printed text.
- *Spatial contiguity principle*. People learn better when corresponding words and pictures are placed near each other rather than far from each other on the page or screen.
- *Temporal contiguity principle*. People learn better when corresponding words and pictures are presented at the same time rather than in succession.
- *Segmenting Principal*. People learn better when a multimedia lesson is presented in user-paced segments rather than as a continuous unit.
- *Pre-training principle*. People learn more deeply from a multimedia message when they receive pre-training in the names and characteristics of key components.
- *Modality principle*. People learn better from graphics and narration than from graphics and printed text.
- *Multimedia principle*. People learn better from words and pictures than from words alone.
- *Personalization principle*. People learn better from a multimedia presentation when the words are in conversational style rather than in formal style.

- *Voice principle.* People learn better when the words in a multimedia message are spoken by a friendly human voice rather than a machine voice.
- *Image principle.* People do not necessarily learn more deeply from a multimedia presentation when the speaker's image is on the screen rather than not on the screen.

In addition to the twelve instructional principles, Mayer (2009) provided nine advanced principles.

- *Animation and interactivity principles.* People don't necessarily learn better from animation than from static diagrams.
- *Cognitive aging principle.* Instructional design principles that effectively expand the capacity of working memory are particularly helpful for older learners.
- *Collaboration principle.* People learn better when involved in collaborative online learning activities.
- *Guided-discovery principle.* People learn better when guidance is incorporated into discovery-based multimedia environments.
- *Navigation principles.* People learn better in environments where appropriate navigational aids are provided.
- *Prior knowledge principle.* Instructional principles that are effective in increasing multimedia learning for novices may have the opposite effect on more expert learners.
- *Self-explanation principle.* People learn better when they are encouraged to generate self-explanations during learning.
- *Site map principle.* People learn better in an online environment when presented with a map showing where they are in a lesson.

- *Worked-out example principle*. People learn better when worked-out examples are given in initial skill learning.

The cognitive theory of multimedia learning is learner-centred and cognitive-constructivist oriented. It focuses on finding effective instructional methods rather than a specific technology. This makes it very relevant in current educational applications.

Action theory

Based upon a "theory of action" Argyris (1976), and Argyris and Schön (1974, 1978), discussed an *action theory,* also called *double loop learning theory*. Here, the focus is on solving problems that are complex and badly structured. It is necessary to change underlying values and assumptions. An important aspect is the distinction between what individuals think and what individuals actually do.

Double loop learning is a theory of personal change that is oriented towards professional education, especially related to leadership in organizations. In double loop learning, assumptions underlying current views are questioned and hypotheses about behaviour are tested publically. The end result of double loop learning should be increased effectiveness in decision-making and better acceptance of failures and mistakes.

Swieringa and Wierdsma (1992) developed the *collective loop learning theory*. Collective learning means organisational changes. At the level of *single loop learning* this applies to changes in the rules, the agreements on how we collaborate, what we must do or what we are allowed to do within the present system. This may only result in a number of minor improvements. With double-loop-learning people bring the shared insights forming the basis of the rules into play. Now people will learn new principles. This means opinions, reasoning, and theories. The double loop learning may result in renewal of the processes or renewal of the structures in the organisation. The *triple loop learning* theory applies to changes in the communally shared principles on which the organisation is based. It represents collective learning at the level of courage and will, and it results in development and major changes of the behaviour of the organisation.

Dual coding theory

The *dual-code memory model,* or the *dual coding theory,* (Paivio, 1971, 1978, 1983, 1986, 1990, 1991; Clark and Paivio, 1991) proposes a verbal system for processing and storing linguistic information and a separate non-verbal system for spatial information and mental imagery. These systems can function independently, but are also interconnected. Several researches have confirmed dual coding (Di Virgilio & Clarke, 1997; Hodes, 1998; Kulhavy, Lee & Caterino, 1985; Paivio, Walsh & Bons, 1994; and Sadoski, Goetz, & Avila, 1995). The dual coding theory predicts that all learners, regardless of their modality, will learn best when they receive combined verbal and visual messages.

Mayer (1993) and Moreno, and Mayer (2000) have been interested in how verbal and visual memories interact. They focus on facilitating memory. Memory is greater when a verbal and a visual code are activated at the same time, rather than only one of them. The image is centrally important in facilitating long-term retention, at least for adults (Paivio, 1983, 1986, 1991).

In part, the dual coding theory draws from the theory of embodied cognition that asserts, "flexible, contextually changing networks of mental representations of sensory experience are the basis of knowledge and thought" (Sadoski, 2006, p. 40).

According to Winn (1993) it is generally agreed that information presented in pictures is encoded twice, once as a picture and once as a verbal label that names the picture. The redundancy in memory that results from this "dual coding" (Paivio, 1971; 1983) or "conjoint retention" (Kulhavy, Lee, & Caterino, 1985; Schwartz, 1988) means that information can be retrieved either from the pictorial or from the verbal memory. It is also known that our memory for a picture-word combination is superior to our memory for words alone, or our memory for pictures alone (Adams & Chambers 1962; Haber & Myers, 1982). Careful integration of words and pictures engage people more effectively than words or pictures alone (Sadoski & Paivio, 2001).

Accoding to Klatzky (1980) dual-code theorists have accepted that mental images are not exact copies of external pictures. Instead mental images contain information that was encoded after perceptual analysis and pattern recognition. In accordance with Anderson (1978) images are organized into subpictures at the time of perception. Paivio (1986) further explained that mental representations have their developmental beginnings in perceptual, motor, and affective experience and are able to retain these characteristics when being encoded so that the structures and the processes are modality specific. (See the section *Modalities*.)

Under ideal conditions, mental imagery has been demonstrated to be effective as an aid to learning of prose. Pressley (1977) found that when eight-year-olds were instructed on forming mental images, given practice at imaging, and were provided separate times for reading and imaging (as opposed to simultaneous reading/imaging), their memory of story content was significantly improved. Early studies established that when learners are told how to process visual information, their performance improves (e.g. Levin et al., 1974). Several studies confirm the finding that imagery strategies particularly aid poor readers and poor learners (Levin, 1973).

Using visuals to complement texts is an effective rehearsal strategy in facilitating learner achievements (Dwyer, 1978, 1985). Visual rehearsal allows the learner to process information simultaneously at several levels. Rehearsal activity provided to students significantly influences the performance of students (Dwyer, 1994). Pictorial representation of information has a tendency to reduce learner dependence on verbal comprehension skills. Other memory models include a single-code memory model approach. All information is coded as abstract propositions. Complex cognitive processing of information involves the use of both visual and auditory cues. Using both verbal and visual material causes dual encoding. This gives the reader a greater chance of recalling the information at a later date, thus being able to use the information as the foundation on which to build further cognitive structures.

Practical application theories

This group includes theories on how to apply knowledge of attention, perception, and systems for mental processing in the production of information sets and learning materials. At present this field of knowledge includes two areas of knowledge: 1) design of teaching aids, and 2) cognitive theory of multimedia learning.

Design of teaching aids

When Adams and Chambers (1962) simultaneously presented auditory and visual stimuli results revealed a net superiority of bi-sensory over uni-sensory responding when stimulus events were certain. Information that is shared between sensory channels will facilitate learning. Cues that occur simultaneously in auditory and visual channels are likely to be better recalled from memory than those cues presented in one channel only.

Levie and Lentz (1982) found that 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.

Memory for a picture-word combination is superior to memory for words alone or memory for pictures alone (Adams & Chambers 1962; Haber & Myers, 1982). 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). Mayer et al. (1996) found that visual explanations are more impactful for inexperienced students, and combining image and text facilitates mental links.

At the end of the 1980s Mayer (1989a) introduced the *model of meaningful learning*. Next version was the *cognitive conditions for effective illustrations* (Mayer & Gallini, 1990). It was also called the *dual-coding model* (Mayer & Anderson, 1991, 1992).

Mayer et al. (1995) built a theory of meaningful learning from components of the *generative learning theory* (Wittrock, 1974, 1989) and the *dual coding theory* (Clark & Paivio, 1991; Paivio, 1971, 1978, 1983, 1986, 1991). The *generative theory* was close to the *theory of meaningful learning* or *generative theory of textbook design*.

In the *"generative theory of textbook design"* learning is viewed as a constructive process in which learners select and build cognitive connections from different pieces of knowledge. The first constructive processes involve attending to visual and verbal information. Information is moved from sensory memory to short-term memory. The learner must select relevant information from the presented words and build a verbal representation or a "text base." Similarly the learner selects relevant information from the illustrations and builds a visual representation, an "image base." In the next step the learner must reorganize the text base into a verbal mental model of the situation described in the text. The final step is to build one-to-one correspondence between the visual and verbal representations.

Mullet and Sano (1995) concluded that (p. 71): "The dominant position of imagery in human communication confers both the greatest opportunity for success and with the greatest risk of failure." When handled correctly, however, effective use of imagery can make a product more engaging and enjoyable.

Cognitive theory of multimedia learning

Based on Baddeley's *theory of working memory* (Baddeley, 1986, 1992) and Paivio's *dual coding theory* (Paivio, 1986; Clark and Paivio, 1991) our working memory has separate auditory and visual channels. The limited capacity assumption is based on Sweller's *cognitive load theory* stating that each subsystem of working memory has a limited capacity (Sweller, 1988, 1994). The *generative theory of multimedia learning* was presented in 1996 (Mayer, 1997; Mayer et al., 1996) followed by the *cognitive theory of multimedia learning* (Mayer, 1997), or *dual-processing model of multimedia learning* (Mayer & Moreno, 1998). This theory posits that meaningful learning requires constructing connections between visual and verbal representations of a system.

Multimedia explanations allow students to work easily with verbal and non-verbal representations of complex systems. Based on the dual coding theory, the cognitive load theory, and the constructivist learning theory Mayer (1997) argued that active learning occurs when a learner engages three cognitive processes: 1) selecting relevant words for verbal processing, 2) selecting relevant images for visual processing, and 3) organizing words into a coherent verbal model and organizing images into a coherent visual model, integrating corresponding components of the verbal and visual models. Moreno and Mayer (2000) presented six *instructional design* principles for this theory.

- *Split-attention principle*: "Students learn better when the instructional material does not require them to split their attention between multiple sources of mutually referring information."
- *Modality principle*: "Students learn better when the verbal information is presented auditorily as speech than visually as on-screen text both for concurrent and sequential presentations."
- *Redundancy principle*: "Students learn better from animation and narration than from animation, narration, and text

if the visual information is presented simultaneously to the verbal information."

- *Spatial contiguity principle*: "Students learn better when on-screen text and visual materials are physically integrated rather than separated."
- *Temporal contiguity principle*: "Students learn better when verbal and visual materials are temporally synchronized rather than separated in time."
- *Coherence principle*: "Students learn better when extraneous material is excluded rather than included in multimedia explanations."

This theory is based on three assumptions: 1) the dual-channel assumption, 2) the limited capacity assumption, and 3) the active processing assumption (Mayer and Moreno, 1998; Mayer, 2003). Moreno and Mayer (2000) concluded that presenting a verbal explanation of how a system works with an animation does not insure that students will understand the explanation unless research-based principles are applied to the design. Multimedia presentations should not contain too much extraneous information in the form of sounds or words.

Generally multimedia researchers define multimedia as the combination of text and pictures (Mayer, 2005a). The words can be spoken or written. The pictures can be animations, illustrations, photos, or video. Multimedia learning occurs when we build mental representations from these words and pictures. Multimedia instructional design attempts to use cognitive research to combine words and pictures in ways that maximize learning effectiveness.

According to the *cognitive theory of multimedia learning* learners build combined mental representations from words and pictures and they learn more deeply than they could have with words or pictures alone. Mayer (2009, p. 59) defined learning as a "change in knowledge attributable to experience." Learning is internal and personal and it cannot be directly observed. It must be inferred through a change in behaviour.

Acccording to Koumi (2013, p. 89): "UK Open University multimedia packages are typically produced over several script conferences by a team of experienced teachers who know their target audience well." Over time such a team develops a *tacit, intuitive design model.* In his article Koumi: "seeks to pull together these tacit design models and make them explicit." He offered forty detailed, usable micro-level, design guidelines for design of pedagogic harmony between spoken commentary (oral text), visual texts (text displayed on the screen), and images in multimedia packages.

However, according to Koumi (2013, p. 102) the cognitive theory of multimedia learning with its six principles exemplify the mismatch between the research literature and the concerns of practitioners who are actually producing multimedia packages. The principles are "too all embracing." For example the split-attention effect leads to the either/or recommendation that audio text is always superior to screen text. Sadoski (2006) concluded that the use of graphics, pictures, and videos with matching text is effective in learning especially with multimedia formats.

Interpreting image content

We know that visuals are perceived much more rapidly and readily than text (Fleming & Levie, 1978, 1993; Sinatra, 1986). Sometimes image-enhancements intended to improve the interpretation of image content get in the way of the actual message (Vogel, Dickson, and Lehman, 1986). A number of studies demonstrate how graphics act as strategies that activate learner's cognitive processes along both horizontal and vertical planes (Winn, 1980, 1981, 1982, 1993; Winn and Holliday, 1985). It is easier to learn left to right sequences than the other way around.

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.

Pettersson (1999) presented hundreds of opinions about image functions in communication. More than one hundred different explanatory verbs are used in the literature 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 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 most common purposes of pictures in the school environment are 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, which differ from culture to culture and may 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 and time frameworks.

We know that the information provider may have many different intentions when they use pictures. However, we do not usually know how people perceive and interpret pictures?

Image associations

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.

Pettersson (1995b) studied what kind of associations people get from viewing slides and how people interpret pictures in advertisements. In the first study 52 subjects generated 385 associations to six slides. In the second study 50 subjects provided 300 associations to six pictures in advertisements. Both studies showed that pictures could generate a great variety of associations in audiences. It was concluded that pictures used in information and instructional materials always need captions to guide the intended understanding of the content.

There is often a considerable disparity between the sender's “intended message” and the receiver's “perceived message” (Pettersson, 1985, 1988). Indeed, it is sometimes doubtful whether the receiver has understood anything at all of what the sender wants to convey. Listeners and readers create their own associations and chains of associations. As far as ambiguous pictures are concerned there is often a major difference between their denotation, i.e., their literal meaning, and various connotations, i.e., their associative meanings and private associations (Pettersson, 1993, 1995).

Image association study

In order to further observe what kind of interpretations pictures may cause in different people I have designed and conducted another “Image association study” (Pettersson, 2003). The main hypothesis is that different assignments to a picture will 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:

1. What does this picture represent?
2. What happens in the picture?
3. Where did you first look in the picture?
4. What do you think of when you see this picture?
5. Why do you think so?

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:

1. Different assignments to a picture will influence the meaning in the mind of the viewer.
2. Realistic photographs can generate a great variety of associations in audiences. Visual experience is subject to individual interpretation.
3. Humans, especially their faces, are the kind of image content that will get maximum attention.
4. Quite often perceived image content is different from intended image content.
5. 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.

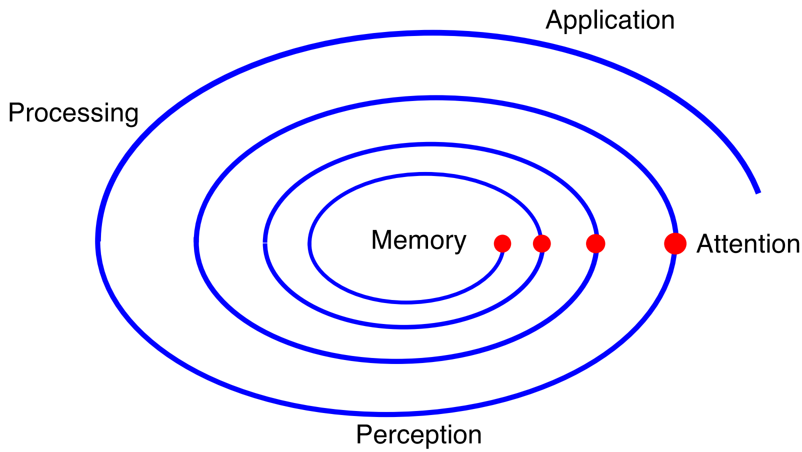
Application of knowledge

After attention, perception, and processing of the information we apply our new knowledge and test it in different applications for confirmation. It is important to use new knowledge. We will remember relevant and meaningful information if we have use for it. The usefulness of conclusions made by other people is limited. We must gain confirmation through our own experiences. The information must be internalized and made our property, as part of our memory.

New impressions are dependent on and interpreted against a background of our previous experience and learning, our attitudes and interests, our needs and feelings, and the prevailing situation. We direct our attention to things that are large, have a bright colour, move, deviate from the surroundings or familiar patterns, things that arouse feelings and needs, and things in which we happen to be interested in at the moment. Memory and experience are successively developed and act as a "cement" in learning. Our previous memory will influence our new learning. This is often very good. Learning in a familiar area is easier, more effective, and more rapid than learning in any new areas. Good experience of previous successful learning is a very good prerequisite for learning of new material. On the other hand, previous "bad experiences" and failures will often have a negative effect on learning in the same area. We may be afraid of new fiascos.

Attention makes us receptive to specific data and information in our environment (external context). We select and perceive information that we process into knowledge with reference to our earlier experiences and memories (internal context). We apply and test for confirmation. Hereby, knowledge is internalized and influences new attention. Different learning processes are active at the same time. Information is processed into knowledge with continuous parallel and spontaneous learning. This is the "Learning Helix."

The learning processes do not always start as a direct result of external impulses or "outside" information. Sometimes, an association initiates a conscious process of thought. We may create new knowledge from the experiences and knowledge that we already have. These processes often take place at a subconscious level, and then we are not aware of the processes. That is why we suddenly can get good ideas and solutions to problems that we have had for a long time. It can be concluded that we need to apply and use what we learn. We will remember relevant and meaningful information. Knowledge is internalized, and made our property as part of our memory.



The Learning Helix. Attention (red dots) makes us receptive to specific data and information in our environment (external context). We select and perceive information that we process into knowledge with reference to our earlier experiences and memories (internal context). We apply and test for confirmation. Hereby, knowledge is internalized and influences new attention.

Wileman (1993) provided the following checklist with questions for evaluation of visuals with reference to "imagination" (p. 97):

- Does the visual "connect" to the learner's existing knowledge and interest?
- Does the visual have a style that relates to the other visuals being used in this lesson?
- Does the visual gain the attention of the viewer?
- Does the visual hold the interest of the viewer?
- Does the visual present the information in a way that helps the viewer remember the information?

Höijer (1998) argued that cognitions such as interpretations, conceptions, ideas, images and memories always include emotions. Things are good, bad, boring, engaging, indifferent; we get upset, feel ambivalent, and so on. Cotton (1995b) noted that we have six primary emotions that are universally accepted and recognized by people all over the world no matter what language they speak or what culture or race they belong to. These emotions are: anger, disgust, fear, happiness, sadness, and surprise. There are three components of any emotion. These components are: 1) internal perception, 2) body changes, and 3) resulting behaviour. According to Cotton (1995b) we can learn to increase our personal effectiveness if we learn to cope with our own emotions. The first skill is to recognize a true emotional response and to be able to identify "faked" emotions.

Cognitive style

People are different in many aspects, also when it comes to cognitive aspects and ways of learning. It is possible to distinguish between different cognitive styles and learning styles.

The relationship between the two terms, *cognitive style* and *learning style*, has found different viewpoints in the literature. The term cognitive style has often been used interchangeably with learning style. However, Claxton and Ralston (1978) argued that cognitive style was only a type of learning style. Keefe (1979, 1982) extended this view of cognitive style as a subcategory of learning style. In accordance with Keefe, learning styles are cognitive, affective, and physiological traits that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment. In accordance with Messick (1970), "cognitive style" describes the learner's typical modes of perceiving, thinking, problem solving, and remembering of information. Messick also indicated that each cognitive style has distinct abilities. Each individual has preferred ways of organizing all that he or she sees, remembers, and thinks about. It is possible to organize these styles dimensions in a general way as they concern reception, concept formation, or retention.

One dimension of the concept cognitive style is "field independence" and "field dependence" (Witkin et al., 1962; Messick, 1970; Witkin et al. 1971). Field-independent persons tend to perceive things clearly from the surrounding background and to be highly analytical and systematic, which may be important when interpreting image contents. Field-dependent persons tend to be influenced by background, and perceive the stimulus of the field in which it is embedded as global. Field-independent persons tend to use internal sources of information in perception and problem solving, and to differentiate among experiences. Field-dependent persons tend to refer to external sources of information and to see experiences as integrated.

Moore and Moore (1984) suggest that repetitive subliminal television captions that supplement visible captions may be an effective device for reducing differences in achievement attributable to cognitive style in learning from television programmes. Beaver (1994) noted that we do not learn anything about things that are of no use or no interest for us or that we dislike. In general, field-independent learners are inclined to reorganize or restructure information to suit their specific learning needs; whereas, field-dependent learners are global in that they depend on the external cues, and available structure in the stimulus field (Witkin et al. 1977). The level of field independence for subjects can be determined by their relative performances on the Group Embedded Figures Test (GEFT), as defined by Jackson, Messick, and Myers (1964). Numerous studies show that field independents and field dependents do learn differently, and that field independence/field dependence is an important instructional variable (Dwyer and Moore, 1994). In accordance with Dwyer (1994), learners possessing different levels of field-dependence or independence learn quantitatively different amounts from visuals that vary significantly in terms of visual complexity.

Entwistle and Marton (1986) have described the context of learning, and the experiences and feelings of the learners. They found that university students often concentrated on an all-embracing and superficial learning on a low cognitive level. This means a passive and unreflecting attempt to memorize, and to later repeat the content of a text. A higher cognitive-level learning means an active effort to actually understand the main points and the message in a text or in any other learning material.

Learning style

Louis Leon Thurstone (1887–1955) was a pioneer in the fields of psychometrics and psychophysics (1937, 1938). He opposed the notion of a singular general intelligence and formulated a model of intelligence centred on seven primary *mental abilities*: 1) verbal comprehension, 2) word fluency, 3) number facility, 4) spatial visualization, 5) associative memory, 6) perceptual speed, and 7) reasoning. Thurstone introduced the term *learning style*.

The concept *learning styles* refers to several theories regarding differences in how people learn. According to these theories all people can be classified with respect to their way of learning. However, there are differing views on how the styles should be defined (Gardner, 1983, 1991, 1993; Geering, 1988; Hansson, 1988; Honey & Mumford, 1986; Jung, 1964, 1965, 1971; and Kolb, 1984). The idea of individual learning styles has had a great influence on education, and it has also been included in teacher education and adult education programs, and it has also been included in teacher education and adult education programs in many countries.

Kolb (1984) defined a learning style as a marked preference for one of the modes on each axis in his learning theory. Thus Kolb got four learning styles:

- Accomodators–active and concrete–problem solvers.
- Divergers–reflective and concrete–imaginative and creative.
- Assimilators–abstract and reflective–thoughtful and theoretical.
- Convergers–action-oriented and theoretical.

Honey and Mumford (1986) developed a questionnaire with 80 items based on Kolb's learning model. In this model the four learning styles are called: 1) Activist, 2) Reflector, 3) Theorist, and 4) Pragmatist.

An *activist* is a person who prefers the concrete experience mode. Activists involve themselves fully and without bias in new experiences. They enjoy the here and now and are open-minded. Activists tackle problems by brainstorming.

A *reflector* is a person who favours the reflective observation mode. Reflectors like to stand back to ponder experiences and observe them from many different perspectives. They collect data and prefer to think about it thoroughly before coming to any conclusion. Reflectors like to consider all possible angles and implications before making a decision.

A *theorist* is a person who prefers the abstract conceptualization mode. Theorists adapt and integrate observations into complex but logically sound theories. They think problems through step by step. Theorists are keen on basic assumptions, principles, theories models, and systems thinking.

A *pragmatist* is a person who favours the active experimentation mode. Pragmatists are keen on trying out ideas, theories and techniques to see if they work in practice. They like to get on with things. Pragmatists are practical people. It is noted that every person has a part from each of these four learning styles.

Geering (1988) discussed eight learning styles:

- Extroverted thinker.
- Introverted thinker.
- Extroverted feeling type.
- Introverted feeling type.
- Extroverted sensation type.
- Introverted sensation type.
- Extroverted intuitive type.
- Introverted intuitive type.

The extroverted thinkers abound in management, military strategy, and some forms of science. The introverted thinkers are often interested in ideas for their own sake. The extroverted feeling types are deeply interested in other people. The introverted feeling people include those who agonize over the world's problems but internalize them and assume them as a burden. The extroverted sensation people love sports, seek thrills, and pleasure. The introverted sensation types find the outer world uninteresting and unsatisfying and they turn inwardly to seek fulfilment. The extroverted intuitive people enter new relationships with great gusto but do not always prove dependable.

They can move quickly from one new interest to another, especially if it is not immediately fruitful. They have visions of new worlds to conquer or to build. The introverted intuitive people include visionaries and dreamers, who draw from their own hidden resources.

Hansson (1988) identified four basic learning styles:

- Sensing–thinking learner.
- Sensing–feeling learner.
- Intuitive–thinking learner.
- Intuitive–feeling learner.

The sensing–thinking learner prefers instruction that focuses on facts and especially on the physical manipulation of tangible objects. He or she likes to know exactly what is expected in each situation. The sensing–feeling learner prefers instruction that focuses on personal values and support for one another. The intuitive–thinking learner prefers instruction that focuses on the meanings and relationships of data. The learner likes problems that require logical analysis and reasoning. The intuitive–feeling learner prefers instruction that allows for personal exploration of a subject or content of personal interest.

There are more models for learning styles. However, this term is used in different ways in different disciplines. Also see the use of the term *modality* in the section "Educational psychology" and the term *learning style* in the section "Educational theory" below.

Modalities

The word "modality" is used as a term for concepts in quite different areas such as cognitive theory, education, educational psychology, educational theory, learning, linguistics, medicine, multimedia, music, semiotics, sociology, theology, transportation, and visual analysis.

Educational psychology

In “educational psychology” modality refer to inner, mental activities and experiences. It is mainly a *reception* perspective. According to Richardson, (1983, p. 23–24) “conscious thought is represented in the form of images, but depending on the context of the thought and upon an individual’s preference for representing it in one way or another, these images are likely to be mainly visual or mainly verbal. While the content of a visual image is “pictured” to oneself, the content of a verbal image is “spoken” to oneself.” (Also see the section *Selection of information.*)

According to Duffy (1983) people may have auditory modality, kinaesthetic or tactile modality, visual modality, or a combination of these modalities. Some people have a mixed modality. In the USA, Duffy reported, 25% of elementary school children have auditory modality, 15% have kinaesthetic modality, and 30% have visual modality. The remaining 30% have a mixed modality. However, some authors refer to these modalities as ”learning styles” (see below).

Children with *auditory modality* rely very much on hearing and verbalisation. They are *auditory learners* and learn by hearing. Thus, these children remember names rather than faces. They learn from verbal directions and descriptions. They think in sounds. Auditory modality children talk a lot. They like to hear their own voices. Auditory learners miss significant details in pictures. However, they may appreciate a work of art as a whole. They favour music.

Children with *kinaesthetic* or *tactile modality*, or both, rely very much on their movements and muscular involvement. They are *kinaesthetic learners* and learn by doing, and remember what was done rather than what was seen or heard. Imagery is not important, nor pictures. Kinaesthetically oriented children prefer sculptures that they can touch. When communicating, these children use many bodily expressions. They respond to music by physical movements.

Children with *visual modality* rely very much on seeing things and on their internal visualisation. They are *visual learners* and learn by seeing. Thus, these children remember faces rather than names. They must take notes and write down verbal information if they need to remember it. Visual modality children are very quiet. They cannot listen for a long period at a time. Visual learners have vivid imagination. They think in images and visualize in components and details rather than the whole. Visual learners are not particularly responsive to music.

Children with *mixed modality* learn from visual, auditory, as well as kinaesthetic and tactile stimuli. They are *multimodal learners*.

Also see the previous section “Learning styles” and the section “Educational theory” below.

Educational theory

In educational theory the term *learning style* is used in approximately the same way as the term ”modality” is used in “educational psychology.” Auditory, kinaesthetic, and visual learning styles are said to comprise different systems, through which we interpret our day-to-day experiences (Smith, 1996). *Auditory learners* learn by hearing. *Kinaesthetic learners* learn by doing. *Visual learners* learn by seeing.

Here "learning styles" are often defined as "... characteristic cognitive, affective, and physiological behaviours that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment" (Ladd & Ruby, 1999, p. 363) or as "personal qualities that influence a student's ability to acquire information, to interact with peers and the teacher, and otherwise to participate in learning experiences" (Grasha, 1996, p. 41). Incorporating learning styles in education can facilitate learning for students (Babbage, Byers & Redding, 1999; Kazu, 2009).

According to the *learning styles theory* people prefer to process information in different ways. People will learn more effectively when they receive information in a way that conforms to their preferences (Pashler, et al., 2009). Thus learning should increase when information is presented visually to a visual learner, and auditory to an auditory learner. Since the 1960s the idea of individual learning styles has had a great influence on education, and it has also been included in teacher education and adult education programs in many countries.

There are, however, many opinions with respect to learning styles (Coffield et al., 2004). Some argue that there is a lack of evidence to support the view that matching teaching and learning styles is educationally significant (Geake, 2008; Pashler, et al., 2009). Some argue that the majority of empirical research suggests that the model is not at all accurate (Fridley & Fridley, 2010; Mayer, 2011). *It seems that learning styles instruction may have no effect on student learning* (Allcock & Hulme, 2010; Choi, Lee, & Kang, 2009).

Also see the previous sections *Learning styles* and *Educational psychology*.

Semiotics

In "semiotics" modality refers to the channel or mode by which signs and representations are transmitted. "Multimodal messages" combine various modes of representation and the interplay between these (Griffin, 1992; Kress and van Leeuwen, 2006). According to Jewitt (2009, p. 14) "multimodality" describes approaches that understand communication and representation to be more than about language. Thus multimodality attend to the full range of communicational forms people use, such as body language, gaze, gesture, image, posture, sound, speech, and so on, and the relationships between them. Contemporary media messages are characterized by a high degree of semiotic complexity and combine various modes. Multimodality can be analyzed from both *production* and *reception* perspectives (Holsanova, 1999).

Social semiotics and modality

In social semiotics van Leeuwen (2005, p. 168) discussed four types of expressions: 1) abstract modality, 2) naturalistic modality, 3) technological modality, and 4) sensory modality. Here it is important to look at the relation between the text and its broader social or cultural context.

Abstract modality simplifies the content of a statement in a way that makes the message clearer. A message may include abstract expressions like charts and thematic maps.

Naturalistic modality is often based on redundancy between the claim of truth and the visual representation. A message may include non-manipulated photographs.

Technological modality is based on "usefulness." It is used in user manuals. Visual truth is based on the practical usefulness of the image. The more an image can be used as an aid for action, the higher its modality.

Sensory modality influences the reader emotionally. A message may cause pleasure or displeasure.

Words and pictures

In "visual analysis" modality means how real a representation should be taken to be (Machin, 2007, p. 46). Here photographs that bear a truthful witness to an event have got "high modality." Such images reflect what we would have seen had we been there when the photographs were captured. Modality can be decreased or increased. 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, detail, light and shadow, and tone. For example the "degrees of the articulation of detail " is a scale ranging from the simplest line drawing to the sharpest and most finely grained photograph (Machin, 2007, p. 57).

In accordance with Bagget (1989), elements coming from different modalities can become parts of the same concept. For example, the name of an object, what it looks like, and the actions one performs on it can be included in a single concept. In a dual-media presentation, visuals should be synchronous with verbal information, or precede the verbal information by up to seven seconds. Bagget found that college students comprehend information in a film just as well when visual and verbal elements are presented simultaneously as when they are presented sequentially, doubling study time.

Lang et al. (2003) discussed seven "rules" to make news video content easier to process mentally and increase comprehension and memory:

1. Let the emotions talk.
2. Slow it down.
3. Dare to be quiet.
4. Match the audio and video.
5. Know how to deal with negative images.
6. Take a literal approach and use concrete images.
7. Use chronological narratives.

According to the "modality principle" multimedia materials that present both verbal and graphical information should present the verbal information in an auditory format and not as written text (Moreno & Mayer, 2000). Sadoski (2006) concluded that the use of graphics, pictures, and videos with matching text is effective in learning especially with multimedia formats.

Improve your own learning

Based on research in psychology it is possible to provide guidelines for more effective learning. The guidelines presented below are selected from many possible guidelines and based on a large amount of recent research (Cotton 1995a, 1995b, Dryden & Vos 1994, Hannafin & Hooper 1993, Mellander 1993, Ormrod 1989, Pettersson 1993, Winn 1993).

Improve the general prerequisites for learning

For learning to occur you must be mentally prepared to learn. You must be interested and curious. You must be willing to learn!

- Be positive.
- Get an enthusiastic mentor.
- Work together with other learners.

- Use relevant and meaningful material from different sources.
- Use different representations and different media.
- Use all your senses.
- Eat a good breakfast and a good lunch every day, preferably including fresh vegetables and fruit.
- Exercise regularly to oxygenate the blood.

Improve attention

The learning process starts with attention, such as curiosity, excitement, expectation, or fear. In pedagogy this is called motivation.

- Pay attention to important information, and think about why this information is important.
- Avoid mental overload.
- Minimise distractions and establish your priorities.
- Determine your best learning times. Do not leave your learning tasks to the last minute.

Improve perception

Human perception is only sensitive to changes in stimulation. You actually perceive less than all you see and hear, and much of the information is never used. At the same time, you perceive more than you see and hear. You believe that you see and hear things that are not there. Your brain fills in missing information. Accurate identification can be made from the correct perception of just a few parts.

- Break large tasks into smaller ones. Summarise information.
- Make sure that you understand the problem at hand.
- Acknowledge your biases.
- Read pictures and captions carefully.

- Seek out additional information.

Improve processing
Information is converted into experiences and insights that are converted into knowledge. We need to understand the function of both our short-term memory and our long-term memory. There are special learning techniques.

Short-term memory
- Organise information into larger units.
- Rehearse information.
- Put essential information in long-term memory as soon as possible.
- Make notes.

Long-term memory
- Work mentally with new information. Review and reflect.
- Learn and store information in a meaningful and organised way.
- Relate new information to what you already know.
- Place realistic expectations on yourself. Reward yourself.
- Use learning techniques.

Learning techniques
- Imagine that your brain-cells are organised like trees, storing related information on its branches.
- Try arranging key points of any topic on a sheet of white paper in the same tree-like format.
- Start with the central topic in the centre of the page. Draw branches spreading out from it.
- Record a word or a symbol for each point you want to recall.

- Put related points on the same main branches, like sub-branches.
- Use coloured pencils or markers for related topics.

Improve application

It is important to use new knowledge. We will remember relevant and meaningful information if we have use for it. The usefulness of conclusions made by other people is limited. We must gain confirmation through our own experiences. The information must be internalised. Here are guidelines for application of information.

- Practice and use new knowledge as soon as possible.
- Apply new knowledge to various situations.
- Convert new knowledge into skills and attitudes.
- Add new knowledge when necessary.
- Teach others.
- Apply the Japanese concept "kaizen," continuous improvement.

Improve your reading skills

There is no doubt that we learn a great deal from reading. Here are some guidelines for improving your reading skills. These guidelines are based on the PQRST-method (Preview, Question, Read, Self-Recitation, Test), a method intended to improve students' abilities to study and remember material presented in textbooks.

- Relearn how to read efficiently.
- Be an active, and not a passive, reader.
- Increase your vocabulary. Learn the relevant terminology.

- Look for usable information. Preview the chapter at hand to get an idea of its topics and sections. Read the chapter outlines, the section headings, and the summary.
- Skim the text with a pencil at hand. Read the pictures and captions. Mark keywords and make notes of important messages. Read the important sections. Look for relationships and conclusions.
- Find answers to the questions what?, who?, when?, where?, how?, and why? while you read the text.
- Add structure to the text. Summarise the text with keywords and notes. Add missing information.
- Test the result of your learning. Rehearsal improves your memory. Read keywords and notes. It is a good idea to repeat this after a day, after a week, and after a month. Compare your new knowledge with your own experience.
- The optimum time for learning from reading seems to be 20-40 minutes. Do not spend too much time. Take a break.
- Get several opinions. Read about the same topic in different books. Use your new knowledge and compare different views.

Improve your listening skills

Listening requires concentration.

- Be an active rather than a passive, listener.
- Analyze the structure of the presentation.
- Distinguish between relevant and irrelevant information.
- Ask the presenter for explanations when needed.

Facilitating theory for ID

There are numerous competing and complex theories of *learning, memory,* and *knowledge*. There is an on-going debate, and there are many different views. Acquisition of knowledge involves complex cognitive processes, such as attention, perception and learning. These processes are influenced by our earlier experiences and our memories. Groups of brain cells are activated and associate to each other. Information is converted into experience and insight.

The information designer needs to *facilitate* attention, perception, learning, processing, and memory of the messages provided in layout, pictures, and texts in information materials. The intended audience must be able to notice the message, and then mentally process the data. It is important to have clear objectives.

The *facilitating theory for ID* includes, but is not limited to, the following four fields of knowledge: 1) attention theories, 2) perception theories, 3) processing theories, and 4) practical application theories. See all these sections earlier in this book.

"Attention theories" includes two areas of knowledge: 1) capacity theories (with filter theory, pertinent stimuli theory, and pre-attentive processing theory), and 2) resource models.

"Perception theories" includes four areas of knowledge: 1) clarity theory, 2) figure and ground theory, 3) gestalt theories, and 4) affordance theories.

"Processing theories" includes four areas of knowledge: 1) schema theory, 2) constructivist learning theory, 3) action theory, and 4) dual coding theory.

The *facilitating theory* contributes to information design with valuable facts, practices, principles, and theoretical approaches. Here are some facts, hypotheses, and postulates based on the facilitating theory.

1. We are not able to attend to more than one stimulus at a time.
2. Graphic form, pictures, sound, and words compete for our attention.
3. Information materials must get attention, and constantly redraw the attention in order to hold the interest of the viewers alive.
4. A presentation may hold the viewer's attention when the rhythm, layout, and pace are not predictable and too boring.
5. Texts with good typography will be noticed in a positive way.
6. Headings with bold and bright colours will get attention.
7. Pictures of the human figure, in particular pictures of the face, get attention.
8. Perception entails fast, holistic, parallel, and simultaneous processing.
9. The main goal in information design is clarity of communication.
10. The *closure principle* is based on our tendency to perceive complete figures.
11. The *common fate principle* is based on our tendency to perceive objects that move together in the same direction as collective entities.
12. The *continuity principle* is based on our tendency to perceive a slow and gradual change in a stimulus as one stimulus.

13. The *contrast principle* is based on our tendency to array impressions that form natural opposites in groups, and reinforcing one another.
14. The *good form principle* is based on our tendency to perceptually group elements together if they form a pattern that is orderly, regular, and simple.
15. The *grouping principle* is based on our tendency to perceive small elements that are arranged in groups as larger forms.
16. The *objective set principle* is based on our tendency perceive some phenomena more strongly than others.
17. The *proximity principle* is based on our tendency to perceptually group events, objects, and units on the basis of their proximity to one another.
18. The *similarity principle* is based on our tendency to perceive and group our impressions on the basis of their similarity.
19. New information is mentally integrated into an existing body of knowledge.
20. Usually receivers are capable of interpreting far more content in a given picture than the designer had in mind.
21. The interplay between text, visuals, and graphic form needs to be studied and tested thoroughly before optimal combinations can be found.
22. Contradictory messages often create more confusion than they provide help.
23. Words, such as "click here," can describe desired actions in screen design.
24. In graphic design of screen displays, physical affordances play only a minor role, so other principles must be invoked.

25. Metaphors can aid screen design.
26. Designers need to help students to construct their own meaning instead of structuring it for them.
27. The information designer needs to know the audience.
28. Pictures must always be explained in information and learning materials.
29. Close coordination between audio and video improves memory and understanding.
30. Our memory for pictures is superior to our memory for words.
31. Illustrations should always be presented in close connection to the discussion in the text.
32. Multimedia presentations should not contain too much extraneous information in the form of sounds or words.
33. There is a difference between what individuals think and what they do.

Learning from representations

Verbal languages have digital codification with combinations of letters or numbers, or both, representing content (Elkind, 1975). There is no direct correspondence between groups of letters, words, and reality. Each meaning is defined and must be learned. In contrast to this, non-verbal languages have analogical codification with combinations of basic graphical elements (dots, lines, areas, and volumes) for likeness of a (concrete) reality (Pettersson, 1983b). Usually, there is a correspondence with reality. Visuals are iconic. They normally resemble what they represent. The meaning is apparent on a basic level but must be learned for deeper understanding. Gombrich (1969) argues that no pictorial image gains the status of a "statement," unless an explicit reference is made to what it is supposed to represent. Barthes (1977) uses the term "anchorage" to describe the relationship of pictures to captions or other accompanying verbal language. Most pictures are capable of several interpretations until anchored to one by a caption.

Learning from text

The perception of linear representations, such as music and text, requires slow and sequential processing (Perfetti, 1977; Sinatra, 1986). In the USA the average person speaks about 135 words per minute (Judson, 1972) and the fastest professional television or radio announcers speak about 150 to 160 words per minute. Reading is much faster. Our top reading speed is some 720 words per minute (Lawson, 1968). Text, spoken and written, is always linear and must be processed sequentially – word by word. In printed text we learn from static lines that are dictated by the technology of the printing press. It is a common fact that reading or listening to a text with long sentences, many difficult and infrequent words, abstract concepts and a high number of adjectives and adverbs impede comprehension.

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 (Lawson, 1968; Ekwall, 1977) and 60–90 seconds to read it aloud (Sinatra, 1986). The intended receiver must get the time that is necessary for reading a text. In verbal and visual languages prior experience and context are very important to the perception of contents.

Pupils in primary school often believe that all necessary information is communicated in the verbal text in textbooks (Løvland, 2011, p, 39).

Reading

A text can convey information, contain analyses and describe feelings and facts (Melin, 1986b). Word identification is a multistage process, which will take some time (Sinatra, 1986). The right brain hemisphere makes an analysis of the visual information. Word naming and word meaning are processed in the left hemisphere (Pirozzolo & Rayner, 1979). In accordance with Sinatra (1986), the meaning of well-known phrase units may be accomplished without activating the auditory-motor speech system. This is done by rapid interchange of information between the language centre in the left hemisphere and its non-verbal representation in the right hemisphere. Utilizing specific textual structure *does not facilitate* recall of instructional text (Frase & Schwartz, 1979; Hartley, 1980). However, utilizing specific textual structure facilitates recall of instructional text (Bernard, 1990; Frase & Schwartz, 1979).

Reading objectives

Gunnarsson (1982) discussed five different categories of reading objectives. What differentiates them is the kind of stored knowledge that must be invoked before any understanding takes place. These five categories are not distinctly delimited; they partly overlap:

1. In memorization of the textual surface, the objective is to create a visual memory of the surface of the text.
2. In registration of the content as such of the text, the objective is to understand the structural and conventional importance of the written message.
3. In comprehension of the sender's description of reality, the objective is to understand what the sender means by the text.
4. In integration of the text into one's perception of one's own surroundings, the objective is to integrate the text into one's own earlier experiences and observations.
5. In direct, action-related comprehension, the objective is to know how one should behave in different situations, based on what the text says.

The first objective involves reading in order to recognize each word and memorize the text surface, while the second requires us to read and understand the words in the text. With objectives three to five, reading is directed towards individual sentences, parts and the whole of the text, and other proficiencies and ideas are brought to bear on the material. Objective three, for example, obliges the readers to interpret the text in terms of the sender's situation. Objectives four and five require that they interpret the text in terms of their own surroundings and world view.

Purpose of reading

Möijer (1987) stated that we read in different ways, depending on the purpose of our reading:

1. We *read intensively*, every word and line, when our purpose demands it.
2. We *skim* if we only wish to quickly get some idea of the material.
3. We *read to orient ourselves* if we want to know where some particular information is to be found in a text.
4. We *read to inform ourselves* when we need certain limited information.

In each of these cases, we leave out anything that does not satisfy the purpose of our reading directly. Different reading objectives (Gunnarsson) or reading purposes (Möijer) attached to reading give rise, therefore, to different reading purposes. These purposes differ in terms of the level of text on which the reader focuses, and in terms of how the material is processed.

Reading skills

Reading is a very important means of learning about our environment. The more a person reads, the more the reading skills improve. Several researchers, however, have reported that large amounts of text cause eye fatigue (Bradshaw, 2000). Depending on the purpose, we can read a text in several ways. An active reader makes good use of the structure embedded in the book and in the text. The preface, the table of contents, the headings, as well as the captions and the illustrations provide an overview of the content in the whole book.

An active reader is skilled in skimming the text. Skimming enables the reader to pick out key words and main ideas in the text and, thereby, obtain a great deal of information. Some texts contain so little new information that skimming is all that is required. Before reading a chapter in a textbook, it is helpful to skim the material to identify key topics and to gain a general idea of the structure of the chapter. Difficult material, however, cannot be fully comprehended by skimming or by speed reading (Atkinson et al. 1990).

Gunnarsson (1982) discusses specific reader characteristics from the perspective of the "schemata theory," which is based on the premise that we store our impressions of our surroundings in the form of schemata. The theory postulates that we have different partial impressions, such as, general knowledge about different types of text, and different whole impressions of reality. Our deeper understanding of a text is influenced by the schemata that we bring to the fore when we read.

In "normal reading," we direct our attention towards how we shall interpret the meaning of a sentence. Studying the syntax becomes subordinate to orienting our thoughts amid the semantic and pragmatic relationships that form the text's warp and woof. When we read long continuous texts, we process separate sentences with an eye to their integration into the material's entirety. This takes place gradually, with the text that we have already read providing the framework. The connection makes sense of the text. Text comprehension is a constructive process, in which the readers build their perception of the whole by integrating the text with their own experiences and memories.

Understanding verbal content

In verbal and visual languages prior experience and context are very important to the perception of contents. Perception of verbal content is apparently easier when a text is read than heard. Therefore it is easier to assimilate and profit from a rich language by reading than by listening. It is also known that pictures that are relevant to the content of the text will facilitate learning from reading prose (Levin, Anglin & Carney, 1987).

The *linguistic usage* as well as the *style* should be correct to avoid distracting the readers. Style is dependent on the choice of words, consistency, expressions, picture elements, symbols, and graphic design. Abstract words, jargon, long and complex sentences, passive constructions, and stilted language may obstruct reading. Long and complex sentences require more cognitive capacity to process than short and simple sentences. It takes time to read a difficult text. We have to decode words, and maintain new concepts in working memory (Petros et al., 1990). There are a vast number of style guides and publication manuals available. Such documents outline standards for design and writing for a specific publication or organization.

When Pappas (2006) examined some 400 information books used in science in the elementary grades she found seven patterns. Six patterns form a continuum from typical information texts to narrative linguistic features. The seventh category has a presence of poetic language. Pappas concluded that information books consist of both typical and atypical features. Both types of books are useful depending on the manner in which they are used. Typical information books are best used to teach scientific concepts and to teach children about the discourse of science. Atypical books are most helpful when they are used in conjunction with typical information books in science. Furthermore, for children to really learn science, they must learn the unique language.

Readers often struggle with understanding the information presented in science textbooks because main ideas are embedded in superfluous and irrelevant information (Roseman et al., 1999; Standsfield, 2006). Graesser et al. (2002) and McTigue (2009) found science textbooks to be difficult to comprehend because of their abundance of abstract content, lack of coherence, and technical terms.

Text structure

Headings on different hierarchic levels will provide the readers with reference point and help them to organize information cognitively for better retention and recall (Jonassen, 1982).

One difficulty of reading science texts is the common use of graphics, specifically diagrams, charts, maps, and other visual information contained within texts (Hegarty et al., 1996; Hannus & Hyona, 1999). The increased presence and variety of graphical information in science texts present another layer of difficulty (Ebbers, 2002; Martins, 2002; McTigue, 2009; Moss, 2001).

While the inclusion of graphics is often intended to help the reader, it creates another layer of complexity (Hannus & Hyona, 1999) that suggests that this process is not natural but that it demands specific skills (Kress & van Leeuwen, 2006; Weis et al., 2003).

Illustrations that are not relevant to the content in the text can have a *negative effect* on reading comprehension and prose learning (Evans, Watson & Willows, 1987; Furnham & Williams, 1987; Gunter, 1980; Levie och Lentz, 1982; Levin, Anglin, & Carney, 1987; Massoumian, 1989; Melin, 1999b; Pettersson, 1993; Rieber, 1994; Schwarz & Stamå, 2006; Sims-Knight, 1992; Sung-Hee & Boling, 2010; Winn, 1993).

Memory from reading

We learn to sequence information, and as a consequence, to think in linear, sequential ways. In accordance with Perfetti (1977) and Sinatra (1986), perception of text means a sequential, slow processing to compose and comprehend the contents ("left brain activity"). Retrieval from verbal memory is a serial integration and sequential processing of auditory-motor perception systems (Sinatra, 1986). One of the best-known techniques for improving memory from reading is called the PQRST method (Preview, Question, Read, Self-Recitation, and Test). The method is intended to improve students' abilities to study and remember material presented in textbooks. In the first step, the reader previews the chapter at hand to get an idea of its topics and sections, reading the chapter outlines, the section headings, and the summary. The second, third, and fourth stages apply to each section. Try to answer questions like what, who, when, where, how, and why? This will improve learning. An active reader adds structure to the text and summarizes the text with keywords. The fifth step, the test, takes place after finishing the work with the chapter. The PQRST method relies on three basic principles for improving memory:

1. Organizing the material
2. Elaborating the material
3. Practising retrieval

We best remember what we read at the beginning and at the end of a reading session. The optimum time for learning from reading seems to be 20-40 minutes (Atkinson et al. 1990), then it is time for a pause. We will forget most of what we learn if we do not rehearse the material. After finishing reading, it is time for the first rehearsal, reading keywords and notes. It is a good idea to repeat this after a day, after a week, and after a month. Klare (1985, p. 15) concluded that readers tend to recall better when writers present information:

1. In cause–effect and contrast arrangements rather than in list arrangements.
2. As straightforward (i.e. explicit) relationships rather than those requiring inferences (i.e., implicit).
3. In parallel constructions (i.e., with parts of a sentence parallel in meaning also parallel in structure), rather than in non-parallel constructions.
4. With repeated words and ideas, rather than words which occur only once and ideas which are novel.
5. Tied to a reader's prior knowledge, rather than not tied to a reader's prior knowledge.
6. In main ideas, rather than in details

Learning from reading text is affected in the same way as comprehension. What can be recalled is typically related to how well it was understood in the first place. Rouet et al. (1995) noted that although a large number of studies have been devoted to the cognitive processing of single text passages, far less is known about the comprehension process in using multiple documents for learning. In two studies they found that 11th grade students' knowledge increased after reading multiple history documents on the same subject.

Listening

Speech does not come to us as a series of individual words. As previously noted hearing a sentence, a word, or even a syllable requires the listener to integrate a changing pattern of auditory stimulation. This integration demands some form of short, temporary buffer storage, and it is likely that perception relies heavily on such temporary sensory memory stores that holds a representation of the initial sounds until the entire word has been heard. Thus we must extract the words from a stream of speech.

The recognition of words in continuous speech is a complex process. Phonemes are recognized even though their pronunciation is affected by neighbouring sounds and by individual accents. Carlson (1993) noted that our recognition of words in continuous speech is far superior to our ability to recognize them when they have been isolated. We use contextual information in recognizing what we hear.

Pressley and Miller (1987) reviewed experiments concerning children's listening comprehension and oral prose memory. They concluded the following ordering of conditions with respect to their potency for affecting children's learning of prose:

- Sentences + complete pictures > sentences + two incomplete pictures.
- Sentences + two incomplete pictures (that is, partial pictures) > sentences + single incomplete picture.
- Sentences + single incomplete picture > sentences only.

Pressley and Miller (1987) have written their review as a reflection of Paivio's dual-coding approach to memory (Paivio, 1971, 1983, 1986, 1991). Memory is greater when a verbal and a visual code are activated at the same time, rather than only one of them (Mayer, 1993; Moreno and Mayer, 2000). Cotton (1995b) defined four major levels of listening skills when a teacher is talking or instructing. These levels are:

- Skim listening.

- Surveying listening.
- Search listening.
- Study listening.

Most people listen only intermittently and select only things of personal interest. When we study, we take an active part in the content of the material. We read texts, we listen to music, we read pictures. This consciously perceived information is processed, sorted, and stored in certain parts of our long-term memory. In the case of a picture, we may need to focus on different portions of it a number of times (so-called "eye fixations") to be able to describe it later on.

Learning from visuals

With their many meanings visuals create ambiguity in the reception in a way that most expressions of written language does not (Limburg, 1987). Just as we learn to read texts, we can also learn to "read" pictures. Tailoring pictorial language in all media is therefore essential so the degree of "reading" difficulty increases progressively in, e.g., school textbooks. It is reasonable to assume the following regarding informative and educational pictures:

- A picture that is easy to read and understand conveys information better and more readily than a picture that is difficult to read and understand.
- A picture evoking a positive response conveys information better and more effectively than a picture evoking a negative response, when motivation is identical in both instances.
- A "poor" picture may work well when motivation is high, but a "good" picture would then work even better.

- An easily read picture can be assumed to have a greater functional, communicative impact than a picture that is difficult to read.

It takes a long time to convey a verbal message. Non-verbal information, however, seems to be processed very fast. It only took a few seconds for adult subjects to recognize “two birds” when shown a picture of two flying House Martins (Pettersson; 1989, 1993). Processing of visual information starts with attention and perception. Learning from images is different from learning from text (Sinatra, 1986).

In order to comprehend visuals, we must be able to process images simultaneously; we must process them in a parallel fashion. We have to learn to read and comprehend the contents of an image. In accordance with Salomon (1979), the process of extracting information from messages that are presented in any symbolic format involves mental activities. In order to make a match between the symbols and their referents in the learner’s cognitive schemata, translation or transforming activities are needed. Such processes differ as a function of the symbolic systems used to convey the message. In accordance with Gazzaniga (1967) and Sperry (1973, 1982), perception of two- or three-dimensional representations means parallel, simultaneous, holistic, and fast processing (“right brain activity”). Lodding (1983) concluded that the image memory and processing capabilities of the human mind are extremely powerful.

Equivalence in verbal and visual information was found significantly superior to verbal or visual dominancy in its effect on spontaneous recall. Presentations characterized by visual dominancy or equivalence in verbal and visual information were found significantly more comprehensible than presentations characterized by verbal dominancy. Visual dominancy was revealed to have the highest positive effect on generalizations, followed by equivalence, whereas verbal dominancy presentations achieved the lowest generalisation scores. The effect of channel dominancy on inferential activity interacted with the viewing condition: when viewers were exposed to the visual channel only, visual dominancy elicited a higher degree of inferential activity than the presentations characterized by verbal dominancy or equivalence.

Zimmermann and Perkin (1982) argued that it is necessary to adequately discuss and explain pictures, otherwise they will probably not be properly understood. Norman and Rumelhart (1975, p. 17) stated that "The fact that a person 'perceives images' when recalling perceptual experiences from memory does not mean that information is stored within memory in that way. It only implies that they are processed as images." Pylyshyn (1973) argued that pictures cannot be stored as complete point-to-point representations, because both the processing and the storage for each picture would be enormous, and therefore overload both the sensory system and the brain.

Bertoline, Burton, and Wiley (1992) discussed three primary stages of visual learning. These steps are: 1) visual cognition, 2) visual production, and 3) visual resolve. Visual cognition includes: 1) visual perception, the ability to mentally comprehend visual information; 2) visual memory, the ability to mentally store and retrieve visual information; and 3) visualization, the ability to mentally create and edit visual information. Visual production includes 1) externalisation, the ability to create and edit visual products throughout a design process; 2) transmission, the ability to communicate information through visual products; and 3) reception, the ability to comprehend responses to visual products. Visual resolve includes the ability to comprehend the termination of a design process.

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).

A huge body of experiments on learning from visual media exist. However, many of these experiments suffer from severe weaknesses in the experimental designs, in the selection of materials, or in the selection of subjects and their treatment. The main exception from this is the "Program of Systematic Evaluation," PSE.

Program of Systematic Evaluation

In 1965 by Francis Dwyer at Penn State University in the USA initiated the Program of Systematic Evaluation, PSE. Dwyer wanted to identify visual materials that are effective in facilitating student achievement of different educational objectives. 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, 1994). Throughout the 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. The heart content was selected because of its motivational value, and because it permitted evaluation of different types of educational objectives. Test formats exist in both verbal and visual versions.

Students' knowledge of specific facts was measured with a terminology test. An identification test measured students' ability to identify positions of the different parts within the heart. Students' ability to reproduce the parts of the heart in their correct contexts was measured with a drawing test. A comprehension test measured the students' total understanding of the function of the heart. It was found that visual testing is a valid strategy for assessing students' learning from visualized instruction. According to Dwyer (1985) the effectiveness of a visual learning environment is primarily dependent on the following factors:

- The amount of realistic detail in the visual.
- The method for presentation of the visual.
- Student characteristics, such as intelligence and prior knowledge of the subject matter.
- Educational objectives.
- The technique used to focus student attention on the essential learning characteristics.
- The type of test format (verbal, visual, etc.) used for the test.

The PSE has progressed through three phases. The results substantiate the fact that the human being is a very complex organism and that the variables that influence learning are extremely complex (Dwyer, 1994). During the first phase of the PSE the basic conceptual rationale for the program was developed (Dwyer, 1972). In my view, it is possible to draw some general conclusions from these early experiments:

- When visual discrimination is needed, pictures are helpful in identifying the various parts of the heart. The use of visuals does not always automatically improve the achievements of the learners. For some objectives text is enough.

- The effectiveness of a visual depends on the medium, on the type of information, and also on the amount of time that learners are permitted to interact with the material.
- 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.
- The realism continuum is not an effective predictor of learning efficiency for all types of educational objectives. An increase in the amount of realistic detail will not produce a corresponding increase in learning.
- Increasing the size of illustrations by projecting them does not automatically improve their effectiveness in facilitating the achievement of the learners.
- Aesthetically pleasing visuals may deceive the learners about their instructional value.
- The same visuals are not equally effective for learners in different grade levels, and for learners with different prior knowledge.
- At high school boys and girls learn equally well from visuals when they are used to complement oral instruction.
- 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.
- Using questions to focus the attention of the learners on the relevant visual learning cues does not improve the instructional potential of the illustrations.

In the second phase (Dwyer, 1978) the research findings emphasize the importance of the interrelatedness of variables (for example the degree of realism, cueing techniques, the level of educational objectives, individual differences, the method of presentation, and the testing format) associated with the effective use of visual materials. In my view, it is also possible to draw some general conclusions from these experiments:

- Visuals designed to complement oral instruction does not always automatically improve the achievement of the learners.
- For certain types of educational objectives and for certain types of learners, oral instruction without visualization is as effective as visualized instruction.
- All types of cueing techniques do not equally facilitate the instructional effectiveness of different types of visual illustrations in oral instruction.

In the third phase (Dwyer, 1994) the main topic of the research focused on how different independent variables may be manipulated and combined to facilitate increased student learning from visualized instruction. Also here it is possible to draw some general conclusions:

- In computer-based instruction achievement is enhanced when embedded cueing strategies are integrated.
- 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.
- Pre-program question cueing is more effective than motion and arrows in facilitating student achievement of specific educational objectives.

- Colour coding improves attention, learner motivation, and memory.
- Imagery strategies involving network or information chunking are effective in assisting learners to process new information.
- Externally paced methods of pacing computer-based instruction were more effective in promoting learner achievement than self-paced methods.
- Different rehearsal strategies impact differentially in facilitating student achievement of different educational objectives.
- Learners who are given quality interaction opportunities spend more time on learning, and achieve significantly more on tests measuring specific educational objectives.

According to Dwyer (1994) the Program of Systematic Evaluation will be multi-focused in the future. Dwyer and his associates will continue to explore the instructional effects of intervening variables. Eventually, the PSE will develop prescriptive guidelines for the production of effective visual learning materials. Pictures reinforce our knowledge when they are close to the real experience. The content, the structure, the context, and the format of a visual influence the viewer's ability to perceive its message. In my view there is every reason to assume that the various picture variables play a very important role in our ability to read and understand visuals. A visual that is easy to comprehend provides good learning and memory retention. This makes it a better representation than a picture that the viewer finds difficult to comprehend.

Other visual learning experiments

Cohen, Ebeling, and Kulik (1981) made a meta-analysis of 74 studies that compared visual-based instruction with conventional instruction. They found that students learned slightly more from visual-based instruction than from traditional teaching, but there was typically no difference between the two groups in regard to course completion, student attitudes, or the correlation between attitudes and achievement. Visuals are very useful in learning tasks that involve memory. The information received from visuals appears to remain longer in memory than information received from verbal information. Bagget (1989) stated that information obtained visually is more memorable and "bushier" (p. 119): "Visual material creates in memory far broader nets of associations for already learned concepts. There are more connections in the memory representation when the input is visual."

Kozma (1991) contended that visual symbol systems are better than verbal symbol systems (p. 192): "The bushier nature of representations derived from the visual symbol systems are better for building mental models of the situation than are representations based on audio-linguistic information."

Others have shown that subjects are capable of accurately identifying previously seen pictures (Nickerson, 1965; Paivio, 1971; Shepard, 1967; and Standing, Conezio & Haber, 1979). Haber (1979) felt that our ability to recognize pictures may be described as virtually "perfect." Over a five-day period, Standing (1973) showed subjects 10,000 slides and found that they were able to recognize 83% on a later occasion.

According to Potter and Levy (1969), a person only needed to look at a picture for 1–2 seconds in order to be able to recognize it among other pictures viewed on a subsequent occasion. A child's inability to assign a name to a previously seen picture could be due to the fact that the picture contents were unfamiliar or because the subject's distinguishing features were depicted with insufficient clarity. A child may thus recognize a picture subject but have no idea what to call it.

Loftus (1972) felt that the number of fixations is decisive to our ability to recall a picture. He found that pictures studied by subjects several times were better remembered than pictures studied less often. Brigthouse (1939), Haber and Erdelyi (1967), and Haber (1979) studied how much subjects actually remembered of picture contents. They found that much more time was needed for people to remember pictures than to merely recognize that they had seen them before. Christianson (1990) showed subjects a series of pictures with emotionally charged, neutral, and unusual contents. The experiments disclosed that the subjects concentrated their attention on the central aspect of a depicted event, that is, the thing that surprised them when they viewed an emotionally charged or unusual event.

Backman, Berg, and Sigurdson (1988) researched pictorial capabilities of comprehensive school students. They wanted to know if there is any difference in the pictorial capabilities of intermediate level vs. senior level students in the Swedish compulsory, comprehensive school. *Pictorial capability* comprises the production and reception of visuals. Differences between the pupil categories can be expected with respect to 1) the production of visuals, 2) the analysis of visuals, 3) the perception of visuals, and 4) the communication of visuals. Empirical studies with a random selection of sixty 5th, 6th, 7th, and 8th year students respectively, i.e., a total of 240 subjects, participated.

For *picture production* the assignment was to produce a picture showing sky, mountains, forest, a lake, a house, a field, a meadow, a fence, and two trees. The subjects were supplied with paper, a pencil, brushes, and eight colours (80 min.). The use of tools, the number of colours, colour mixing, perspective, and areas was evaluated.

For *picture analysis* the assignment was to submit answers to questions about the way a picture had been made (40 min.). The presence of comments on shapes, colour, figures, composition, and technique was evaluated.

For *picture perception* the assignment was to submit a written description of everything the test picture conveyed (40 min.). The presence of comments on emotions, imagination, associations, and events was evaluated. *Picture communications* was divided in two parts. For production the assignment was to produce a picture that supplies information about the significance of red and green as traffic signals (40 min.). Communications was evaluated as unequivocal, not quite unequivocal, or incomprehensible.

For *reception* the assignment was to write down the message conveyed by a series of instructive pictures (40 min.). Whether the student understood fully, partially, or not at all was evaluated.

The study comprised a total of 1,200 visual and verbal statements submitted by 240 comprehensive school students. All the evaluations were performed by two of the authors, both teachers of method at the Department for the Training of Visual Arts Teachers at the University of Umeå. The students displayed very poor pictorial capabilities. They were poor at producing pictures and in reading pictures. Only 5% of the senior level students were able to produce a picture that supplied information on the importance of red and green as traffic signals. Only 43% of the senior level students were able to supply a written description of the message conveyed by a series of instructive pictures.

The results showed that the two comprehensive school categories did not display any significant difference in pictorial capability. The teaching of visual arts does not live up to the expectations teachers should have on the basis of existing curricula. There is probably a very considerable need for further training of teachers of visual arts. The authors concluded that teachers of visual arts must adopt a new approach. The subject "visual arts" demands the same competent, cognitive processing as, e.g., English, Swedish, or mathematics. This is quite remarkable since the curricula in Sweden both assume and require all teachers to be responsible for teaching about visuals as means of communications. I agree with Larsson (1991) who wrote (p. 105): "... 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. A corresponding low pictorial capability is probably true for pupils and teachers in most countries.

What we see is very important for our experience and perception of the world around us. Seeing is direct and effortless. Making and understanding visual messages is natural to a point. However, effectiveness in visual literacy can only be achieved through learning. And the ability to read and understand pictures is learned. This learning to understand pictures takes place more rapidly in a culture where pictures are used and seen frequently. Pictures reinforce our knowledge when they are needed. Most people have a preference for visual information (Pettersson, 1993).

Since visuals are being employed to an increasing degree in an increasing number of contexts, the National Board of Education in Sweden proclaimed (Skolöverstyrelsen, 1980) that all teachers are responsible for providing instruction and training in the use of visuals and communications devices (p. 30, and p. 72):

> The ability to express oneself with the aid of a visual is a skill of benefit to many subjects.
> Visuals have become important parts of the contents of many school subjects. So picture analysis should be a natural feature in all teaching.

However, most teachers appear to have insufficient training in the use of visuals in their classes. Teacher training programs do not touch on textbooks and other teaching aids to any great extent. Backman and Eklund (1989) found that Swedish teacher training in the subject visual arts for comprehensive school and high schools is spread out over the entire college program in the form of about 15 "picture and design units" in the old class teacher programs and in two visual arts departments. Backman and Eklund noted the following (p. 26):

> From the autumn of 1988, the weight of courses on "visuals" or "visual arts" in teacher training varied considerably, i.e., 5, 15, 20, 60, and 80 points. It is obviously important for these courses, even if implemented in the correct manner, to reflect the same philosophy. "Visuals" is a narrow subject with no corresponding scientific discipline.

Some county boards of education examined comprehensive school education in the subject visual arts. Arvidsson and Engman (1989), both at the National Board of Education, wrote (p. 2) that: “The review showed that school leaders and teachers of subjects other than the subject visual arts were unaware of the goals of “visual arts” and the subject’s evolution into an important communications discipline in our modern society.” Somewhat later, Arvidsson and Engman observed (p. 4):

> Research on the importance of visuals to our ability to observe, visually conceive and express ourselves touches on factors of major importance to thinking and human behavior. We should keep in mind that the visual is ascribed a role in stimulating both aesthetic and general creativity. Against this background, the importance of visual language to general teacher proficiency has been underestimated, as is also the case for the position of visual arts teaching in school.

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 may be a key factor in effective medical and health education.

According to Santas and Eaker (2009) it is clear that learning from images is not easier or more generalized than learning through written text. However, in science classes students have to deal with concepts that they cannot directly experience. Students need to be correctly guided towards the formation of coherent and scientifically acceptable ideas and reasoning.

According to Clark and Lyons (2004, p. 43) the effectiveness of a visual depends on the interactions among three components in any learning environment, 1) features of the visual, 2) goal and content of the instruction, and 3) differences among individual learners. Learners process visuals differently depending on 1) their prior knowledge of the lesson content, 2) their prior knowledge of visual literacy, and 3) their spatial ability (p. 217).

It may be concluded that pictures can reinforce our knowledge. The content, the structure, the context, and the format of a visual influence the viewer's ability to perceive its message. The variables that influence learning seem to be very complex.

It can be concluded that pictures can have a positive, a neutral, and also 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).

Learning from text and visuals

Jonassen, Campbell, and Davidson (1994) remarked that it would be impossible to imagine an information processing system that would be capable of decoding, and, even less possible be capable of recognising, a visual stimulus using only the auditory senses and sensory registers. Several researchers have noted that the human processing system is a multi-dimensional system that is capable of processing and using different types of information through specialized processes (Atkinson & Shiffrin, 1968; Baddeley & Hitch, 1974; Baddeley & Lieberman, 1980).

Wandersee (1992) wanted to know if biology textbooks can be improved so that students are more successful integrating words and images. He used a traditional and a simulated textbook page with information about the prokaryote-eukayote distinction. The study showed that learners are significantly more successful at identifying unknown cells on unfamiliar micrographs than if they learn from traditional text with a captioned pair of prototype cell micrographs. It appears to be more effective to present examples before non-examples (e.g., nucleated cells before un-nucleated cells), a subtle application of the little-known psychological principle that it is always easier to visually detect the presence of a feature than the absence of it.

Providing illustrations with text is known to usually facilitate learning. Clearly labelled line drawings that isolate important information seem to be the most useful type of illustration (Dwyer, Dwyer and Canelos, 1988). Such visuals help learners to isolate and identify important material, recall prior knowledge, provide interaction with content, and enhance information acquisition. The visuals make the abstract more concrete. Pictures can significantly increase comprehension, recall, and problem solving when they are combined with educational texts. This *picture facilitating effect* depends on the type of the text, the subjects, the testing methods, the type of pictures, and the role of the pictures in the text (de Lange, 1999).

Multiple cueing is of little value unless the information is processed in more than one way (Dwyer, 1978). In an experiment with 300 subjects Cisotto and Boscolo (1995) found that the use of paragraph headings improved learning. However, underlining of relevant information did not have the same effect, it did not improve learning.

To take active part in a linguistic message that consists of text, sound, or pictures – either together or separately, always implies the exertion of effort, that is, work. Reading or listening taxes our faculties; sooner or later we become tired. Furthermore, material that is poorly constructed and presented strikes us as dull, and not only causes our interest in the subject to wane, but leaves us exhausted. This applies irrespective of whether a message is meant to impart information, instruction, or entertainment. It also applies irrespective of the medium of conveyance, except in so far as different media have entirely different capacities for conveying a message from a sender to a receiver.

Pictures in prose

Although approximately one-third to one-half of the space in science textbooks is devoted to illustrations, most textbook illustrations do not appear to serve any important instructional function (Levin & Mayer, 1993; Mayer, 1993; Woodward, 1993). Research on texts, their language, style, meaning, and social meaning has been going on for a long time. In contrast to extensive research on text processing and text design, there has been less research on the potential power of illustrations for fostering learning from textbooks (Houghton & Willows, 1987; Mandl & Levin, 1989; Mayer, 1989b; Willows & Houghton, 1987). In an extensive paper Sims-Knight (1992) reviewed 88 sources on the use of pictures in textbooks. She found that visuals may be effective in their educational function, even if they are unappealing or dull, as long as there is appropriate subject matter content.

By the mid-1970s, it was well established that children's immediate and factual recall of simple fiction was improved when the picture contents were completely redundant with the prose content (Levin & Lesgold, 1978). After reviewing picture effects on children's learning Pressley (1977) concluded that enough research evidence already had been gathered regarding illustrated text. Pressley wrote (p. 613): "No more experiments are required to substantiate the positive effect of pictures on children's learning." More recent reviews (Levie & Lentz, 1982; Levin, Anglin, & Carney, 1987) substantiated the Levin and Lesgold (1978) earlier conclusions. Levie and Lentz (1982) summarized the results of 55 experimental comparisons of learning from illustrated versus non-illustrated text. Levie and Lentz concluded (p. 225–226):

1. In normal instructional situations, the addition of pictorial embelishments will not enhance the learning of information in the text.
2. When illustrations provide text-redundant information, learning information in the text that is also shown in pictures will be facilitated.
3. The presence of text-redundant illustrations will neither help nor hinder the learning of information in the text that is not illustrated.
4. Illustrations can help learners understand what they read, can help learners remember what they read, and can perform a variety of other instructional functions.
5. Illustrations can sometimes be used as effective/efficient substitutes for words or as providers of extra linguistic information.
6. Learners may fail to make effective use of complex illustrations unless they are prompted to do so.

7. Illustrations usually enhance learner enjoyment, and they can be used to evoke affective reactions.
8. Illustrations may be somewhat more helpful to poor readers than to good readers.
9. Learner-generated imaginal adjuncts are generally less helpful than provided illustrations.

Also Houts et al. (2006) found that individuals with low literacy were helped when pictures accompanied the text. Beacham and Alty (2006) found that text-only material was beneficial to dyslexic readers.

Levin et al. (1987) discussed different functions of pictures used in prose. In accordance with them, four functions are "text-relevant." These are called 1) representational function, 2) organisational function, 3) interpretational function, and 4) transformational function.

1. Illustrations are representational when they serve to reinforce the major narrative events in the text and "tell" the same story, that is, are redundant with the text. Representational pictures add concreteness to the prose since memory for pictorial materials is better than memory for verbal materials.
2. Illustrations are organizational when they provide a framework for a text. They add coherence to the prose, since memory for organised materials exceeds memory for unorganised materials.
3. Illustrations are interpretational when they clarify passages in the text that are difficult to understand. Interpretational pictures add comprehensibility to the prose, since materials that are initially well understood are better remembered than materials that are more poorly understood.

4. Illustrations are transformational when the prose contents are re-coded into the concrete form and related in a well-organised context. These pictures provide readers with a systematic means of retrieving the critical information. Transformational illustrations are designed to impact directly on readers' memory.

After a meta-analysis of results from some 100 experiments on functions of pictures used in prose published in 87 separate documents, Levin et al. (1987) concluded that all types of text-relevant pictures facilitate learning from reading prose. There was an increasing learning effect:

- Representational pictures ("moderate").
- Organisational and interpretational pictures ("moderate to substantial").
- Transformational pictures ("substantial").

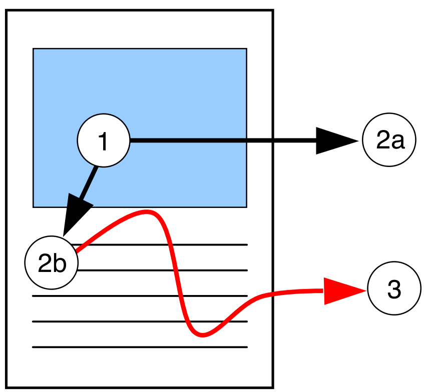
Levin et al. (1987) also concluded that when illustrations are not relevant to the prose contents, no prose-learning facilitation is to be expected. As previously noted illustrations can have a *negative effect* on reading comprehension and prose learning. Therefore illustrations should not be used only for decoration in learning materials. As it is most visuals are too complicated and would communicate better if designers valued simplicity over decoration.

Pre-understanding

Both the reading and the listening processes require decoding of symbols, pre-understanding of words, phrases, and pictures, and, finally, comprehension of the content of the information. Furthermore, in my view the legibility, readability, and reading value of the written message influence the reading process. In the case of the spoken message, the message's audibility, distinctness, and listening value influence the hearing process. An important step in the reading process is pre-understanding. As I mentioned before, the graphical form of a text creates expectations in the reader regarding its content. We often expect certain types of learning material to look in a particular way; contrarily, when we see a document of a certain type we may expect a particular type of text and pictures to accompany it. Thus, it is in the light of these expectations that we activate the cognitive processes needed to interpret the message. The readers develop their own methods for predicting what a text will be about. Introductions, abstracts, tables of contents, summaries, illustrations, and tables all have important functions to fill.

A page in a textbook should always be designed as a fully integrated verbal 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. It seems that we often see the pictures before we read the text.

When we look at the picture 1) we form a pre-understanding of the verbal visual message on the page. We decide either not to read the text (2a) or to read the text (2b). Reading the text and the picture makes it possible to create an understanding of the verbal visual message (3).



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. We also know that images are interpreted in different ways depending on different assignments (Pettersson, 1989).

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 form a mental pre-understanding of the style and the kind of text as well as a pre-understanding of the complete message. 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 makes it possible to create an understanding of the verbal visual message contents.

Television producers are usually good at showing what their programmes are about. In countries with a great many television channels, it has been noted that viewers switch rapidly between different channels until they find a programme that awakes their interest. Sometimes, a viewer will make up his mind within a couple of seconds (Matsushita, 1988). A language that is rich in similes and metaphors makes it easy for the readers to create their own inner images. A well-constructed text with clear, distinct arrangement and lucid paragraph disposition, organized under well-formulated headings and captions affords the best reading experience.

Selection of information

A verbal response to visual stimuli or a visual response to verbal stimuli requires a transformation from one modality to another. Research concerning the effects of verbal as well as visual modalities show that children pay more attention to visual than to verbal information. Zuckerman et al. (1978) found that children tend to be more accurate in recognizing visual than auditory segments in television commercials. Hayes and Birnbaum (1980) showed pre-school children cartoons in which the audio track either matched or mismatched the visual information. In both cases, children had a higher retention of the visual than of the auditory information. (See the section *Modalities.)*

Incompatible channels

Barry (1998) noted that in tobacco advertising in general, the mandatory cigarette warning label is invariably placed outside of the visual scene, a "tack-on" of verbiage in an otherwise complete visual story. Visual design elements invariably draw the eye away from the words. The very fact that the format of the warning is verbal assures that it will be processed differently. The brain does not only process words differently, but their nature is more experientially remote and less involving, particularly for children and adolescents.

Pezdek and Stevens (1984) found that when children had to choose which of two incompatible channels to process, they preferred the video channel. The auditory information sustains attention and facilitates comprehension. Pezdek and Hartmann (1983) found that video without sound reduced comprehension among preschool children. Rolandelli et al. (1985) concluded that children used the auditory component of television to direct attention to important visual information, as well as to process auditory, especially verbal, content.

The eye movements and fixations can be guided and determined by a picture caption or by a spoken commentary. Meaningful material is learned more easily and remembered for a longer period of time than meaningless material. Thus, we are normally forced to make a continuous selection from the information, which constantly bombards us.

Tidhar (1987) studied children's understanding of the content in educational television programs. It was concluded that "Channel Dominancy," the degree to which either the visual or the auditory channel carries the brunt of information whereas the other channel provides compatible supportive information, was found to affect viewer's information processing in areas such as recall, comprehension, generalization, and inferential activity. Equivalence in verbal and visual information was found significantly superior to verbal or visual dominancy in its effect on spontaneous recall. Presentations characterized by visual dominancy or equivalence in verbal and visual information was found significantly more comprehensible than presentations characterized by verbal dominancy. Visual dominancy was revealed to have the highest positive effect on generalizations, followed by equivalence, whereas verbal dominancy presentations achieved the lowest generalization scores. The effect of channel dominancy on inferential activity interacted with the viewing condition: when viewers were exposed to the visual channel only, visual dominancy elicited a higher degree of inferential activity than the presentations characterized by verbal dominancy or equivalence.

Pictorial superiority effect

Many people have experienced how looking at old photographs in a forgotten album can result in a dramatic flow of memories. According to Paivio (1983, 1986, 1991), the image is centrally important in facilitating long-term retention, at least for adults. Paivio (1983) showed that our memory for pictures is superior to our memory for words. This is called the *pictorial superiority effect* (Paivio, 1983; Branch & Bloom, 1995).

It is also known that our memory for a picture-word combination is superior to our memory for words alone, or our memory for pictures alone (Adams & Chambers 1962; Haber & Myers, 1982).

Pictures should be put as close to the relevant text as possible (Benson, 1985; Braden, 1983; Haber & Hershenson, 1980; Hartley & Burnhill, 1977a; MacDonald-Ross, 1977; Mayer & Sims, 1994; Mayer, 1993; Mayer & Sims, 1994; Mayer et al 1995; Moreno & Mayer, 2000; Pettersson, 1989, 1993; Wright, 1982).

Media influences on learning

The basis for the media's influence on its public lies in the mental processes that enable a person to perceive, process and store impulses from his or her environment. Media effects arise through a complex interplay between the potential of meaning inherent in the content of media, the potential of interpretation by its public, and the social context within which media use take place (Waldahl, 1998). Exposure to the same media message does not imply that the audience will benefit equally from it. The comprehension of a message depends on each perceiver's qualifications to understand its content.

Despite easy access, media are not used much in teaching. In accordance with Gustafsson (1980a, 1980b) and Sigurgeirsson (1990), besides books, teachers seldom or never use any media other than overhead transparencies, and even these are used in only 6% (Gustafsson), and 7% (Sigurgeirsson) of lessons. Many teachers frequently use blackboards and books. At low cost these media provide an impressive degree of flexibility.

Few teachers use electronic media in their teaching. Gibbons et al. (1977) wrote (p. 1139):

> … after honest efforts to use electronics media over an extended period of time, many teachers have been unable to see a clear improvement in learning. Hence, electronics media are generally judged by teachers to be inappropriate educational tools for most circumstances.

An explanation for all the media hardware and software in schools, and the use of media in teaching can be traced back to the 1940s and 1950s. The *"realism theories"* include the *iconicity theory* (Morris, 1946), the *cone of experience* (Dale, 1946), and the sign similarity *orientation theory* (Carpenter, 1953). The basic assumption from each of these theories is that learning will be more complete as the number of cues in the learning situation increases.

For teachers it is necessary to understand discipline specific methods and subject content. However, in the future this is no longer sufficient in the mastery of pedagogical expertise. Today interactive and socially engaging technology is transforming learning and teaching in ways that have not been previously seen (Bender, 2012; Ludlow, 2012; Schrum & Levine, 2009).

Learning benefits?

Many researchers have argued that the use of media in teaching actually has no learning benefits. In accordance with Clark (1983), the results of the studies that appear to favour one medium are not due to the medium, but to the method or the content that is introduced along with the medium. Clark sees media as "vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition" (p. 445). Thus, the medium is an inert conveyer of an active stimulus, to which the learner makes a behavioural response.

Clark (1994) concluded that in thousands of media research studies conducted over the past 70 years, researchers have failed to find compelling causal evidence that media or media attributes influence learning in any essential and structural way at all. Media and their attributes have important influences on the cost and the speed of learning, but only the use of adequate instructional methods will actually influence learning.

In accordance with Kozma (1994), learning is not the receptive response to delivery of instruction. Learning is an active, constructive, cognitive, and social process by which the learner strategically manages available cognitive, physical, and social resources to create new knowledge. This is done by interacting with information in the environment and information that is stored in our memories. Reiser (1994) argued that Clark fails to acknowledge the fact that certain media attributes make certain methods possible (p. 45): "Returning to Clark's truck analogy, the successful delivery of frozen foods requires the use of a vehicle with refrigeration." Clark (1994) accepts Kozma's (1994) point that whenever learning occurs, some medium or mix of media must be present to deliver instruction. However, if learning occurs as a result of exposure to any media, the learning is caused by the instructional method embedded in the media presentation. Clark claims that media research is merely a triumph of enthusiasm over substantive examination of structural processes in learning and instruction.

I support Jonassen, Campbell, and Davidson (1994) who advised a shift in the debate and the practice of instructional design from instruction- and media-centred to a learner-centred conception of learning. The debate should focus on the attributes of the human learner involved in learning, and on the role of media in supporting, not controlling, the learning process. Jonassen, Campbell, and Davidson conclude that the most important debate is not about the relative efficacy of instructional components; instead it is the role of learner and the context of learning. While learning, students interact with both media and methods, and it is difficult to isolate the effects of media and methods.

Salomon, Perkins, and Globerson (1991) argue that media should focus on the effects of learners' cognitions with technology, as opposed to the effects of technology. We should see media as facilitators of constructive learning, instead of the conveyors of instruction. Instead of using multimedia to deliver instruction or even create environments for learning, multimedia are better used as environments or tools that enable learners to construct their own artefacts (Kommers, Jonassen, and Mayes, 1992; Lehrer, 1993). In accordance with Ross (1994), both Clark and Kozma may be right. From a positivistic perspective, Clark is correct in arguing that media studies are limited for isolating the instructional strategies or essential "ingredients" that cause gains in learning. But, from an applied perspective, Kozma is also correct in supporting the design of media-based delivery systems by systematically selecting and combining effective strategies/ingredients.

Threlkeld and Brzoska (1994) concluded that sufficient evidence exists to affirm that teaching via media does not violate teaching. The media is a mere vehicle, and successful learning comes from other factors related to learners, support, course design, motivation, and needs. We have gone beyond the initial phase of using media to teach students at a distance, during which we had to demonstrate over and over again that teachers could teach and that students could learn. In accordance with Wolcott (1994), distance education entered a new generation with the rapid advances in telecommunications. Today, synchronous and interactive media can link a widely dispersed group of students in a common instructional dialogue. Instruction is no longer confined to voice communication. Technological developments, such as fax, electronic writing devices, and computers make it possible to transmit visual images and data. Audio teleconferencing deliveries are used extensively and they are effective distance education options.

According to Van Merriënboer (2001) we only know little about the optimal combination of audio, speech, screen texts, and illustrations in multimedia used for education. Some studies demonstrate that spoken commentary is better than visual text seen on the screens (Tabbers, Martens & Van Merriënboer, 2001). In the audio condition auditory and visual inputs can be processed simultaneously in *working memory*, thereby leaving extra capacity for the learning process. Some papers address how learners might cope without a *fixed linear narrative* (Laurillard, 1998; Laurillard et al, 2000) and *split-attention* effects (Moreno & Mayer, 2000). Learners learn better when the instructional material does not require them to split their attention between multiple sources of mutually referring information.

Distance education

Rezabek (1993) pointed out that learners are a crucial variable in successful distance education (p. 111):

> Wise, learner-cantered distance educators will realize that their educational philosophies and classroom strategies that focus the educational act on learners and learning rather than teachers and teaching can be translated to distance situations. Some of these strategies may include the use of student-negotiated learning contracts including identifying the objectives and grading criteria, consideration of student's learning style preferences in instructional planning, and encouragement and validation of student ideas and comments.

In the future, some teachers may be able to communicate with their students in "multi-media distance education classrooms" for interactive distance education and training. These teachers will have access to all kinds of media. They will need completely new skills and methods to be able to handle this new situation. Large companies such as Boeing and Motorola, with employees at multiple geographic locations, have developed their own internal webs, Intranet. They use the internal webs as information and learning tools, and are moving from instructor-based learning to multiple learning formats. In Japan NTT (Nippon Telegraph and Telecom) is developing the concept of the "Open Computer Network" as a new infrastructure with Internet access for multimedia communication between educational projects and corporations.

Thach and Murphy (1995) identified the roles and competencies of distance education professionals within the USA and Canada. The top ten competencies portray the dual importance of both communication and technical skills in distance education. The competencies are (p. 57):

- Interpersonal communication
- Planning skills
- Collaboration/teamwork skills
- English proficiency
- Writing skills
- Organizational skills
- Feedback skills
- Knowledge of distance education field
- Basic technology knowledge
- Technology access knowledge

Starr Hiltz (1993) described the Virtual Classroom. Students at New Jersey Institute of Technology share their thoughts, questions, and reactions with professors and classmates using a computer-mediated conference system. Special software supports asynchronous group-oriented learning processes for distance education. Most students reported that the system improved access to educational activities, and is a better mode of learning than the traditional face-to-face situation in classroom courses. Today similar functions are available within the World Wide Web. An ever-increasing number of schools and universities are now using this concept. One example is Penn State's Commonwealth Educational System in the USA. Another example is The Open University Internet Courses in the UK. The world's first entirely virtual campus is the Open University of Catalonia in Spain (Warden, 1996).

And at Dublin City University in Ireland students at the School of Computer Applications have online access to virtual lectures on the Internet (Smeaton, 1997). Here, traditional course materials was reorganised into a series of segments or topic points; digital audio files from two minutes to one hour long, many with links to pictures stored on web pages. The students can access these segments of information at will using the Internet.

There are four navigation systems: 1) a complete hierarchical table of contents, 2) a comprehensive topic index, 3) a full transcript of the complete audio track, and 4) the visual material with links to other parts of the course. This technology may replace the traditional lecture mode of delivering information to the students. Then the teachers may spend more time helping the students in their learning. Web based training (WBT) should be similar to computer aided learning (CAL). In order to optimise the learning computer aided learning should be combined with person-to-person interaction (Johnson and Johnson, 1986). The Internet offers some solutions to this. Students can communicate with each other via e-mail, bulletin boards and other real time systems.

Collaborators in learning

Passive listening and reading are less effective as a teaching approach (Mathewson, 1999), especially for younger children, while visual representations cannot only attract attention and maintain motivation (Cook, 2006), but they also can illustrate invisible or abstract phenomena that cannot be directly observed or experienced.

Cunningham (1993) noted that we now live in a "Global Society," where the instructor must deal with the multiplicity of effects of socioeconomic, cultural, and linguistic differences. Furthermore, certain groups of people may be less suited for, or intimidated by, the gadgetry commonly used to make presentations. The traditional role of faculty members, in universities as well as in private "training establishments," may change in the future. Emphasis will shift from faculty members that provide students with information to faculty members that provide students with opportunities to find and evaluate information on their own.

The role of faculty members, in universities as well as in private "training establishments," may change in the future. Emphasis may shift from faculty members that provide students with information to faculty members that provide students with opportunities to find and evaluate information on their own. In this new role, faculty members will become collaborators in learning, helping students to find efficient ways to gather information and to make discerning judgments about what is and what is not useful among the over-abundance of available data and information. Teachers can aid students to transform and adjust subsets and fractions of information into connected knowledge. However, teachers are not trained to do this. Walker (1993) reported on the progress of the development of an Engineering Visual Database Index. She noted that eight engineering schools have developed a curriculum designed to meet the educational needs of engineering graduates for the 21st century. This curriculum, "Curriculum 21," predicts several major changes in the way we do things today. Engineering students will change from passive observers to active participants. Memorisation of facts will change to problem solving. Traditional printed text will evolve into visually based presentation of information.

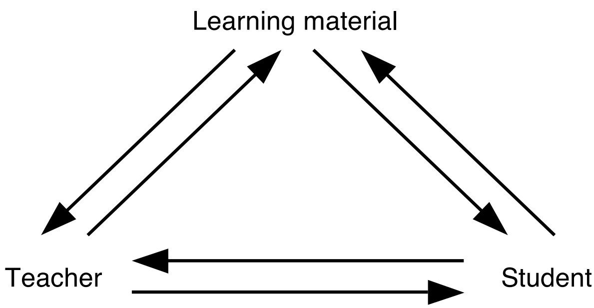
Faculty members can assist in building well-structured, resource-based learning environments. The present development of different compact discs will open up fascinating, new opportunities. The compact discs will make it possible to create "the total learning aid," encompassing text, sound, pictures, numerical information, and opportunities for various kinds of information processing in a single medium. A "total learning aid" is a multimedia database (a hyper-medium) offering the user complete freedom in moving back and forth between verbal, numerical, visual, and audio information. Eventually it may be possible to use all our senses to handle information stored in databases.

Kristiansen et al. (1994) noted that adult learners have a different life situation and a different social environment than normal students. Adult learners often have significant competencies and experiences that should be brought into the teaching process. They want to discuss questions related to their work, and they do not like to be taught. Senn Breivik (1992) noted that very few campuses seriously attempt to teach students how to package information effectively. In the business world, for example, presentations almost always include visuals (Griffin 1989, 1990). Griffin and Gibbs (1993) reported that business people report participating in about one business presentation per month. However, most of today's business students graduate without ever having given a thought to how they might make a presentation using graphics or charts, and generally speaking, people in business are not visually literate.

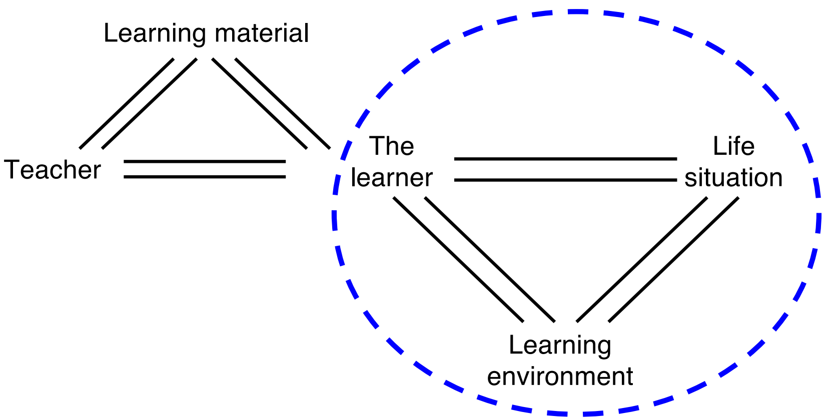
According to Bjørgen (Kristiansen et al., 1994), we assume that learning is a result of a process between the teacher, the teaching material and the student (the pedagogical triangle).

The better the teaching material is, the smaller the need for direct contact with the teacher. In traditional distance education, so much is invested in the teaching material that the student scarcely requires contact and dialogue with the teacher.

We often neglect that student environment is a decisive factor in learning. It is in the local social environment that motivation for learning is established and where the selection of useful learning opportunities takes place. The best effect is achieved when colleagues learn together.



This is the pedagogical triangle according to Bjørgen (Kristiansen et al., 1994. p. 30).



A cooperative learning process is based on dialogue among students, and influenced by their life situations, and their learning environments. (After Bjørgen: Kristiansen et al., 1994. p. 30).

In traditional distance learning, like the Open University in the UK, much work is put into developing teaching material. This requires heavy investment and is based on the assumption that a large number of people shall learn the same subject matter under the control of the teacher, directly or in the way the learning material is designed. It takes between two and three years to develop such a course. The dialogue between the teacher and the student occurs primarily to secure that subject matter content is understood the way it was intended. With complete self instructed material no questions needs to be asked. The development of multimedia teaching programmes corresponds with this model. The material is not flexible, and the teaching is carried out based on the needs of the teacher.

When students work together they take part in a cooperative learning process. Here the dialogue is primarily between students, not with the teacher or with the teaching material. However, some dialogue with the teacher is desirable to secure understanding of the subject matter content. In distance education videophone, telefax, mail, telephone, and electronic mail can be used. According to Kristiansen et al. (1994), the ideal learning situation includes (p. 23):

> ... the best possible contact with the fact about which one is to learn using the senses, the possibility of contact with people of the same ability who can create a good learning environment and with whom one can discuss, the best possible professional and pedagogical preparation with a view to learning and the opportunity for dialogue with helpers. And the most important; a learner who is knowledgeable about the learning process and his own role in it, who is

motivated for the learning work and who believes in himself.

It can be concluded that learning needs complicated cognitive processes. We know from research and experience that teaching will not automatically result in learning. Theorists do not all agree about what learning is and how it comes about. This is further discussed in the next chapter.

Mental processing and message design

The producer of information and learning materials can facilitate communication, and the various learning processes of the receivers. Complicated language, in both texts and pictures, will impair the understanding of any intended message. Thus, text and pictures for information should always be designed so that they are easy to read. Any graphical message should be legible, readable, and also well worth reading for the intended audience. Any audial message should be audible, distinct, and also well worth listening to for the intended audience.

Simplicity in a message will result in easier and more effective perception, processing and memory of that message (Sinatra, 1986). Design has the unique capacity (Mijksenaar, 1997, p. 25) to shape information by:

- Emphasizing or understating.
- Comparing or ordering.
- Grouping or sorting.
- Selecting or omitting.
- Opting for immediate or delayed recognition.
- Presenting it in an entertaining fashion.

In general one can state that information should be as simple, clear, and unambiguous as possible. However, in any presentation, information can be enriched with a wealth of details. The subsections *Processing of text, Processing of pictures, Processing of layout,* and *Processing of colour* provide "process-oriented" guidelines that may be used in the design of messages in information and learning materials.

Facilitating processing of colour

In order to facilitate the processing of colour the information designer should:

- Use colour coding in a consistent way. Inconsistent use of colours will reduce learning (Bradshaw, 1996, 2003).
- Limit the number of colour codes.
- Find out likes or dislikes of colour.
- Use colour coding to increase understanding and learning (Dwyer, 1972, 1978; Epskamp, 1981; Hannafin and Peck, 1988; Bradshaw, 2003).

Facilitating processing of text

In order to facilitate the processing of text the information designer should:

- Design text to facilitate mental processing.
- Use a variety of examples and non-examples.
- Provide the time that is necessary for the receivers to read, interpret and understand the message in the text.
- Divide the text into sections, subsections, and paragraphs to avoid too large masses of text (Jonassen, 1982).
- Set headings in different type versions to aid comprehension of the text content (Jonassen, 1982).

Facilitating processing of pictures

In order to facilitate the receiver's mental processing of pictures the information designer should:

- Use line drawings when study time is limited (Dwyer, 1972).
- Use graphics in a consistent way.
- Use pictures that are relevant to the content of the text. It will facilitate learning from reading prose (Levin, Anglin & Carney, 1987).
- Use realistic versions of artwork when unlimited study time is allowed (Dwyer, 1972; Fleming & Levie, 1978; Soulier, 1988).

Facilitating processing of layout

In order to facilitate the processing of layout the information designer should:

- Use illustrations that are relevant to the content in the text.
- Make close connections between verbal and visual representations.
- Avoid inconsistent use of typography.
- Do not make lines too short, or too wide (Ekwall, 1977).
- Use paragraph headings to improve learning (Cisotto and Boscolo, 1995).
- Use captions to anchor interpretations of pictures (Barthes, 1977).

Memory and message design

As previously seen there is a close relationship between guidelines aimed at providing simplicity and guidelines aimed at facilitating perception, processing and memory. Simplicity in a message will result in easier and more effective perception, processing and memory of that message. The subsections *Memory for text,* and *Memory for pictures* provide “process-oriented” guidelines that may be used in the design of messages and information materials.

Facilitating memory for text

In order to facilitate memory for text the information designer should:

- Present only a limited number of information elements at the same time.
- Provide meaningful contents.
- Present text and illustrations in close connection.
- Use a graphically complex text rather than a “plain” text (Melin, 1999b).
- Use cuing to highlight ideas. The consensus is that readers are more likely to remember cued ideas than un-cued ideas (Hartley, 1987).
- Use specific textual structure in instructional text (Frase and Schwartz, 1979, Bernard, 1990).

Facilitating memory for pictures

In order to facilitate memory for pictures the information designer should:

- Put pictures as close to the relevant text as possible (Benson, 1985; Braden, 1983; Haber & Hershenson, 1980; Hartley & Burnhill, 1977a; MacDonald-Ross, 1977; Mayer & Sims, 1994; Mayer, 1993; Mayer & Sims, 1994; Mayer et al 1995; Moreno & Mayer, 2000; Pettersson, 1989, 1993; Wright, 1982).

- Co-ordinate design of learning materials with a theory of meaningful learning (Fleming & Levie, 1993; Mayer, 1993; Mayer et al. 1995). Mayer et al. (1995) built such a theory from components of Wittrock's (1974, 1989) generative learning theory and Paivio's dual coding theory (Paivio, 1971, 1978, 1983, 1986, 1991; Clark and Paivio, 1991).

Wayfinding and wayshowing

In order to describe his concept of *environmental legibility* Lynch (1960) coined the term "wayfinding" in his book *The Image of the City*. This new concept included the elements of the built environment that allow people to successfully navigate through complex spaces like cities and towns.

Passini (1984) and Arthur and Passini (1992) discussed the concept *wayfinding* in more detail. It refers to the cognitive and behavioural abilities that are associated with how individuals can purposefully reach a desired physical destination (Passini, 1999, p. 88). A good "wayfinding system" allows people to reach their desired destination easily and quickly with as few mistakes as possible.

In terms of "problem solving" wayfinding comprises three major processes: 1) Decision making and the development of a plan of action to reach a desired destination. 2) Decision execution and transforming the plan of action into behaviour of the appropriate place(s) along a route. 3) Perception and cognition, and providing the necessary information to make and execute decisions.

According to Passini (1999, p. 88) the concept "wayfinding" refers to the cognitive and behavioural abilities that are associated with how individuals can purposefully reach a desired physical destination. In terms of “problem solving” wayfinding comprises three major processes:

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- Decision execution and transforming the plan of action into behaviour of the appropriate place(s) along a route.
- Perception and cognition, and providing the necessary information to make and execute decisions.

Wayfinding is distinguished from other types of problem solving by operating in an architectural, geographic, or urban space. In this context “cognitive maps” are parts of information processing. Arthur and Passini (2002) have further developed the “wayfinding concept” and how people search through information loaded environments.

Wayfinding is a term commonly used by designers and manufacturers of signs and signage systems. Mollerup (2005) pointed out that some of them may actually work with wayfinding. However, they have not found their way to precise language. In their work as “sign writers,” they should actually work with the different possibilities to “show the way”. Such messages must be accurately developed and transmitted by the information providers and then correctly interpreted and understood by the receivers or interpreters.

Actually ”finding the way” is the responsibility for those individuals who need to go somewhere. According to Mollerup (2005) wayshowing relates to wayfinding as writing relates to reading and as speaking relates to hearing. *The purpose of wayshowing is to facilitate wayfinding*. Wayshowing is the means. Wayfinding is the end. The introduction of the term wayshowing is an important contribution to information design.

Traditional learning theories

This chapter presents four groups of learning theories: *Perceptual motor-skill learning*, *Associative learning*, *Learning from analysis and problem solving* and *Social learning*.

Perceptual motor-skill learning

Any acquired ability to perform tasks in response to sensory stimuli is often called *perceptual motor-skill, sensory-motor-skill*, and *psychomotor skill*. Perceptual motor-skill ranges from simple imitative movements to physical skills requiring complex neuromuscular coordination. The position of a skill on this continuum is a major determinant of the training approach that we have to adopt. According to Heinich et al. (1982) the psychomotor domain may be seen as a progression in the design of the coordination that is required. They noted four levels of learning objectives in the psychomotor domain:

- *Imitation*: repeating an action which is shown
- *Manipulation*: performing independently
- *Precision*: performing with accuracy
- *Articulation*: performing unconsciously, efficiently, and harmoniously

Some motor acts occur automatically, such as retracting a finger from a fire or any hot item. Many motor skills, however, require practice. Everyday examples are walking and eating. The terms perceptual motor skill, sensory-motor skill, and psychomotor skill all reflect the idea that sensory and motor information must be well integrated to accomplish acts like walking and eating. If a mobile is attached to an infant so that the infant's movements activate the mobile, the infant soon discovers this relationship and seems to delight in activating the mobile with the appropriate kick. Two-month-old babies can learn to do this, but soon forget. Three-month-old babies can remember the correct action over several days (Atkinson et al., 1990).

Most perceptual motor-skill learning requires the combination of many smaller patterns of movement into larger units, and repeated practice to smooth out all the rough spots. Motor abilities are actually a mixture of several basic components and sub-skills. Acquiring a motor skill is often thought to involve three distinct stages.

- In the cognitive stage, the person must comprehend the task requirements.
- During the intermediate stage, the person must apply already acquired motor skills to the new task, integrate the new skills, and avoid unnecessary movements.
- In the third stage the new skill becomes automatic. Then the person does not need to think about each step in the process any more.

While beginners rely mostly on external cues, someone who masters a skill will rely more on internal feedback, such as those provided by muscles. Psychologists call this trial-and-error learning. Although sensory-motor-skill learning can in fact take place without insight, qualitative thinking nevertheless requires a great degree of insight and understanding. A person usually learns a skill more easily with short, widely spaced practice sessions than with fewer and larger sessions. An expert instructor is often helpful to show the learner what a good performance is like, to diagnose and correct errors early in the motor-skill learning process, and to prevent the learning of wrong movements and bad habits. Using mental imagery, and thinking oneself into the role of an expert performer, tends to improve skill performance. Also “self talk” can have a positive effect.

Romiszowski (1993) presented three basic categories of skilled behaviour. Typing is an example of the first group, called “totally reflexive and automated skills.” Here, sensory information is received and triggers a physical action without any significant involvement of the brain. In the second group, skills depend on the recall of a possibly complex, but essentially algorithmic, procedure and the execution of a series of linked actions in sequence. Many industrial and sports skills fall into this category. In the third group, skills depend on the analysis of the incoming sensory information, in order to formulate a plan of action that is appropriate to the situation at hand.

Other skill categories are cognitive, reactive, and interactive skills. Cognitive skills are logical thinking, problem solving, and decision-making. Examples of reactive skills are dealing with attitudes, feelings, and emotions. Examples of interactive skills are leadership and resolution of conflicts.

Associative learning

Associative learning, or learning that certain events go together, is among the most basic forms of learning. In classical times, the ideal product of education was a citizen trained in the disciplined study of a restricted number of subjects: grammar, logic, rhetoric, arithmetic, geometry, music, and astronomy. The mode of learning was based on imitation and memorising, and there was a strong emphasis on the intellectual ability of the teacher, like in the Socratic method of question and answer. This section includes four subsections: 1) Habituation, 2) Conditioning, 3) Associative psychology, and 4) Constructivism.

Habituation

Many events cause animals as well as humans to react automatically. A sudden noise makes us turn toward the source of the sound. If the noise is harmless and it occurs again and again we quickly learn not to respond to that sound. This is called habituation, the simplest form of learning (Carlson, 1993). Habituation permits us to remain relatively free from distractions.

Conditioning

In accordance with the *behaviourist theory*, we learn to act in acceptable ways by being praised and rewarded when we do good things and by praise being withheld when we do not. To get attention, it is most effective to present material in a way that is both interesting and understandable to those who are to learn it. The behaviourist learning is a process of expanding the behavioural repertoire, not a matter of expanding the ideas in the learner's mind. Behaviourism grew in popularity throughout the 1920s, 1930s, and 1940s. There are two traditions within behaviourism: classical conditioning and operant conditioning.

Classical conditioning

In classical conditioning an organism learns that one event follows another. The Russian physiologist Ivan Pavlov studied the process of digestion in dogs. By chance, he discovered that he was producing an interesting change in the behaviour of the dogs. Whenever Pavlov fed the dogs, they started to produce saliva. He found that if he rang a bell at the same time as he fed the dogs, eventually just the sound of the bell led the dogs to salivate. The dogs had been conditioned. This process can be described in three steps:

- Stimulus (food) ---> response (salivation)

- Stimulus (food) + conditioned stimulus (bell) ---> response (salivation)
- Conditioned stimulus (bell) ---> response (salivation)

Pavlov also demonstrated two basic learning principles, those of generalisation and discrimination. He found that his animals tended to give the same conditioned response to a number of different stimuli, such as bells of different pitch. They could be trained, however, to discriminate between bells of only slightly different pitch or other stimuli closely resembling each other.

An example of classical conditioning is the child who, having once been bitten by a dog, exhibits a generalised, conditioned fright response in the presence of other dogs. Learning new vocabularies, new terms and conventions, as well as mathematical, chemical, and geographic symbols all involve some degree of conditioning. To some extent it is a simple instance of stimulus learning. In knowing the sign for something, a person makes a response to the sign, similar to what he or she would make to the real object. This is called sign learning.

Classical conditioning helps to explain children's and adults' strong positive and negative attitudes, feelings, and emotions toward school and teachers. These attitudes, feelings, and emotions may have originated from ease and difficulties in learning school subjects, from teacher interaction, from peer group interaction, and many other stimuli –response situations. "Persuasive communicators" frequently use conditioning principles. Many commercials for alcohol, cars, cigarettes, and perfume employ the classic "sex appeal," so that the product is paired with a stimulating male or female. The assumption is that the product will be tied to a stimulus that is already rewarding to the receiver, and that the sale of the item will thus be enhanced. More than forty years ago Skinner (1953) made the following statement (p. 57): “As advertisers well know, the responses and attitudes evoked by pretty girls, babies, and pleasant scenes may be transferred to trade names, products, pictures of products, and so on.”

Classical conditioning may play an important role in the development of ethnic prejudices. People may not be aware of the reasons for emotional reactions. We may simply conclude that there is something “nasty” or something “nice” about some persons or groups of persons.

Operant conditioning

In operant, or instrumental, conditioning an organism learns that a response it makes will be followed by a particular consequence (operating on the environment, thus the term “operant”). Thorndike studied the learning behaviour of cats, and formulated several “laws of learning.” He showed that animals engage in trial-and-error behaviour. In accordance with his “law of exercise,” the link between a given stimulus and a response becomes stronger the more the pathway is activated. The more a specific behaviour is practised, the more strongly it will be “learned.” Thorndike’s “law of effect” stated that if the response to a stimulus has a pleasing effect, then the probability of the learner repeating the response in any similar situation would increase. The process can be described like this:

Stimulus ---> response ---> reward or reinforcement

Skinner worked with rats and pigeons. He found that an action or a response does not have to be rewarded or reinforced every time it occurs. His “teaching machine” and his “programmed text” work on the principle that humans find that getting the right answer to a question is very rewarding. In both the machine and the text, material to be learned is presented in small units, and the learner work through a series of questions in small steps. When a correct answer is given, the learner receives immediate positive feedback.

Skinner (1954) proposed to have the “total” instructional tools necessary to improve classroom learning. Such programmed learning involves gradually increasing the level of difficulty while continuously reinforcing correct responses and extinguishing incorrect responses. Programmed learning has demonstrated its effectiveness in education, although it has not lived up to its early promise. Critics of Skinner's logic do not accept his deductive applications of laboratory findings to wide-scope hypotheses on human life and society.

Considerable research evidence indicates that we can verbally shape the attitudes of others. Since the 1950s, studies have found that experimenters can influence the frequency by which a person engaged in a specific behaviour by conditioning that behaviour with positive verbal statements, such as “good,” “very good,” and “excellent.” Most teachers are also well aware that praising and rewarding a student for good work is very effective. A reward leads to liking the rewarded task. Negative feedback and punishment leads to dislike of the punished deed. Reward serves as a more effective aid to learning than punishment in human learning. A neutral reinforcer, one that is neither positive nor negative, can become a secondary reinforcer by virtue of being repeatedly associated with reinforcement. Thus, money is a secondary reinforcer because it can be exchanged for positive reinforcers.

In psychological experiments, a verbal reward communicates the attitude of an interviewer to the person being interviewed (Insko and Cialdino, 1969). This communication represents the information conveyed by reinforcement. Here, "good" allows for agreement and conformity to exist. A verbal reward also communicates approval. The more often an interviewer says "good," the better the interviewer-student rapport becomes, and they develop a good relation. In accordance with Insko and Cialdino, both the amount of information, and the rapport are important variables in learning. The behaviourists only describe learning in terms of observable behaviour. Thus, they mix the individual's gathering of knowledge with the generally defined objectives of the learning process itself. The *behaviouristic approach* to conditioning assumes that:

- Simple associations are the building blocks of all learning.
- The laws of association are the same for all species and situations.
- Learning is better understood in terms of external causes than internal ones.

The *ethological approach*, however, challenges these assumptions. In accordance with the ethologists, what an animal learns is constrained by its genetically determined "behavioural blueprint." It seems that most contemporary educational practice is based upon the behavioural stimulus–response–reward model. It sees the student as a *passive receptor of knowledge*. The teacher is the prime actor. Students follow directions, listen to and read the "right answers" and provide the "correct responses."

In today's schools classical conditioning becomes drill and practice. Operant conditioning becomes gold stars and verbal praise. The two basic modes of stimulus–response learning provide an analysis of learning at school. However, the complexity of academic achievement needs much elaboration on the simple stimulus–response models. The assumption that there is a predictable relationship between stimulus and response is basic to many theories of learning. A "stimulus" can be defined as any event that can be perceived by the organism. A "response" can be defined as anything that the receiver does as a result of perceiving a specific stimulus.

Associative psychology

In accordance with associative psychology in the USA, learning is based on associations. A person must have experiences in order to develop ideas. A baby gets ideas by relating or associating his or her own experiences.

The "law of contiguity" states that mental associations occur when two events take place close to each other in space or in time. These events tend to be remembered together. The recurrence of one will bring the other to mind. The "law of similarity" states that a person is likely to connect two things that are almost the same. On the other hand, the "law of contrast" states that greatly different things are likely to be associated. Thus, it is easier to learn the differences between "hot" and "cold," than between "hot" and "warm".

The 19th-century German philosopher Johann Herbart made an important contribution to providing a mental mechanism that determined which ideas would become conscious and which would be left in the subconscious. This was the mechanism of apperception. New ideas became associated with existing ideas. A sequence of steps were presumed to be required to carry out a lesson:

- *Preparation:* whereby the teacher starts the lesson with something already known to the students.
- *Presentation:* introducing new material to the students.
- Association: whereby the new information is compared with and connected (apperception) to the old information.
- *Generalisation:* whereby the teacher presents other instances of the new idea to the students.
- *Application:* whereby the ideas are applied to further material, carried out by the students individually (a problem solving phase).

Psychological research has developed general aids to memorisation, or “learning by heart.” The main suggestion is to learn from the beginning to the end.

Cognitivism

According to *cognitivism,* a perspective in education, people generate knowledge and meaning through sequential development of cognitive abilities. These abilities include our mental processes to analyze, apply, create, evaluate, recall, recognize, reflect, and understand.

As previously noted in Piaget's theory of development (1926, 1936), children adopt a series of schemata to understand the world. Piaget focused on assimilation and accommodation. *Assimilation* is the process of fitting new information into pre-existing cognitive schemas. *Accommodation* is the process of taking new information in one's environment and altering pre-existing schemas in order to fit in the new information.

Bruner (1960, 1966) believed that the goal of education is intellectual development. His theory has four components:

- Curiosity and uncertainty.

- Structure of knowledge.
- Sequencing.
- Motivation.

Bruner recommends that instructors create learning environments that allow students to interact with their environment, connect to prior knowledge, and express the experience either verbally or mathematically. Bruner proposed the spiral curriculum, a teaching approach in which each skill or subject is revisited at intervals, at a more sophisticated level each time.

Vygotsky (1962) asserted that thought development in children is sequential and dependent upon language development linked to their cognitive development. Vygotsky's work demonstrates why abstract concepts must be linked to prior knowledge that is gained sequentially. Children are able to communicate and to learn from others through dialogue.

Behaviourism, cognitivism, and constructivism are the three broad learning theories most often utilized in the creation of instructional environments. Cooper (1993) traced the paradigm shifts in instructional design from behaviourism to cognitivism and then to constructivism. According to Jonassen (1991, p. 10) each individual creates meaning from his or her own experiences. Ertmer and Newby, (1993, p. 66) put it this way:

> As one moves along the behaviourist - cognitivist - constructivist continuum, the focus of instruction shifts from teaching to learning, from the passive transfer of facts and routines to the active application of ideas to problems.

The information age and the technological capabilities have caused us to design new instructional approaches (Duffy & Jonassen, 1992).

Constructivism

A new wave in learning theory to improve classroom learning came from the *constructivism model* (Duffy & Jonassen, 1992; Jonassen, 1991). Constructivism is grounded in the philosophy of Dewey, Kant, and Vico, and the psychology of Piaget, Bruner, and Bartlett. In constructivism knowledge is a function of how individuals create and construct meaning from their own experiences and their own physical and social context and environment.

Constructivists emphasize situating cognitive experiences in authentic activities (Thompson, Simonson, & Hargrave, 1996). Reality is neither unitary nor fixed, but constructed. The mind is central to the constructivist view. Rather than mapping concepts on the mind of the learner (as with objectivism) constructivism attempts to help individual learners construct their own knowledge from their experiences and their understandings of reality. The learner is the central focus in the constructivism model, not the instructor or the teacher.

All individuals have a unique set of experiences, and different perceptions of their own realities. Knowledge is constructed and developed by the individual learner through interaction with her or his environment (Jonassen, 1991; Wheatley, 1991, Steffe & Gale, 1995). Each individual mind builds different symbols. Since each mind develops different symbol structures, each mind perceives reality as well as all kinds of information materials somewhat differently; although common understandings can occur.

Chandler and Doolittle (2000) argued that in general, pedagogy based on constructivism normally includes the following criteria:

- Learning should take place in authentic and real world environments.
- Learning should involve social negotiation and mediation.
- Content and skills should be made relevant to the learner.
- Content and skills should be understood within the framework of the learner's prior knowledge.
- Students should be assessed formatively, serving to inform future learning experiences.
- Students should be encouraged to become self-regulatory, self-mediated and self-aware.
- Teachers serve primarily as guides and facilitators of learning, not instructors.
- Teachers should provide for and encourage multiple perspectives and representations of content.

These constructivist pedagogical statements by Chandler and Doolittle stand in sharp contrast to traditional pedagogy where it is assumed that knowledge can be transmitted, in full, from the instructor to the student, usually by means of lectures or direct instruction. Chandler and Doolittle (2000) demonstrated that it is possible to include constructivism and a constructivistic approach in traditional courses. They found that a "hybrid" course can be less time intensive than a "pure" constructivism course.

Learning is an active process. It happens through interaction with any kind of information material and any kind of environment. Constructivist environments facilitate learning through collaboration, context, and construction of knowledge.

A major assumption in constructivism is that even though reality exists outside language, we can only know and communicate about reality through formal speech and discussion. Media may support constructivist learning environments, but they do not control it. Through assimilation and accommodation, individuals use many elements of the learning context and relate those elements to their own experiences; thus, creating new knowledge. At school the classrooms holds no special status. It is usually important to improve the learning environment in the classrooms.

Kumar et al. (1994) noted that in hypermedia it would be possible to track the performance of individual learners. The flexibility of hypermedia documents with their systems of nodes and links allows the learner to pursue her or his experiences in a self-directed, non-linear way. This is consistent with the constructivist model of learning. Hypertext capabilities, different navigational structures, and content exercises are examples of information design features that enable each individual student to construct knowledge in a constructivist manner. Fee (1999) argued that multimedia and hypertext puts control of much of the computer experience into the hands of the individual learners, allowing them to navigate as they will and access additional information as they desire it. Students can navigate in a non-linear fashion and build their concepts in any manner that makes sense to them. They can make selective use of the materials that they feel are important, necessary, or of the most value at the time. Thus, in many ways hypertext is a powerful tool for creating constructivist learning environments.

Duffy and Cunningham (1996) made a distinction between *socio-cultural constructivism*, or *social constructivism,* and *cognitive constructivism*. The basic difference between these views lies within the context of cognition.

The cognitive constructivist approach focuses on the individual, and her or his construction of knowledge. This is also called *individual constructivism*. The social constructivist focus on the social and cultural processes that affect the individual with learning as a result. Media producers construct their messages. Media show us different versions of reality. *Social constructivism* suggests that knowledge is first constructed in a social context and is then taken up by individuals (Eggan and Kauchak, 2004, cited by Schilder, 2013).

Analysis and problem solving

This section involves intellectual assimilation of information and knowledge, and comprises the following five subsections: 1) Cognitive development. 2) Cognitive learning. 3) Perceptual learning. 4) Aha! learning. 5) The learning hierarchy.

Cognitive development

Cognitive development takes place along with remarkable neurological, physical, and perceptual changes during the first years of life. The learning capacity is said to depend on the number of associative links in the brain, and their accessibility. What learning is and how it develops is a primary concern for scientists interested in human development. Some educational theorists view the education of a child as an unfolding process. The child develops inevitably as a product of nature.

The main function of the teacher is to provide the optimum conditions for this development. This leads to the theory that the child's experience is the essential point. The Swiss educator J. H. Pestalozzi was a leading theorist in this field. His practical schemas were designed to provide the most appropriate experience for the child's development. According to the Renaissance Dutch philosopher Erasmus and the Jesuit Fathers, understanding had to precede learning. The teacher's first task was careful preparation of the material to be taught.

Although the sequence of motor-perceptual experience, followed by symbolic representation, has been advocated for a long time, Jean Piaget offered the first insight in this field. Piaget had an early biological training. Like Dewey, he viewed learning as an adaptive and biological feature. Its biological function was to aid the individual in dealing with the surrounding environment. Piaget particularly worked with his own three children that he studied intensively from their births. He approached the function of thinking and learning in terms of mental or cognitive structures that make thinking and learning possible. According to Piaget, we develop schemata for dealing with and understanding our environment. Piaget claimed that there are stages of intellectual development that all children pass through as they learn certain universal schemata for structuring the world. Piaget argued that assimilation of new ideas was not enough. Accommodation of the established ideas to the new experiences was also required.

Homburger Erikson discussed eight different stages of human development. In each stage we have to face a major crisis. Educators need to be aware that there are stages of intellectual development. In some situations, students may not have developed the logical or conceptual equipment to be ready for and to be able to tackle certain types of problems. A child might know a word, but this is not at all the same as mastering the concept.

Dryden and Vos (1994), claimed that 50% of a person's ability to learn is developed in the first four years of life, and another 30% is developed by the eighth birthday. Those vital years lay down the pathways on which all future learning is based. According to Dryden and Vos youngsters are their own best educators, parents their best first teachers. Simple physical routines can help infants explode into learning. Our homes, beaches, forests, playgrounds, zoos, museums and adventure areas are the world's best schools. Learning anything, including reading, writing and math, can be fun for youngsters as long as it is treated like a game. Teaching based on cognitive theories of learning recognises that readiness to learn comes about through the combination of at least three processes. These three processes are:

- Growth in quality of intellectual activity.
- Prior experience.
- Desire to learn.

Much of the work on reading skills makes use of the readiness concept. The Italian educator Maria Montessori claimed that periods of sensitivity, corresponding to certain ages, exist when a child's interest and mental capacity are best suited to acquiring knowledge of such things as textures and colours, tidiness, and language. The ability to recognise stimuli develops with age. Children of all ages recognise visual stimuli better than auditory stimuli. Learner characteristics, such as age, gender, culture, prior knowledge of the subject matter, scanning habits, and visual and text processing abilities affect learning abilities and learning skills.

Gardner (1983) found that we each have at least seven different types of intelligence. Two of these types, linguistic intelligence and logical-mathematical intelligence, are very highly valued in traditional education. The other five intelligences are musical intelligence, spatial or visual intelligence, kinaesthetic intelligence or physical intelligence, interpersonal intelligence or social intelligence, and intrapersonal intelligence or introspective intelligence. Later he added one more type, 8) naturalistic (Gardner, 1991, 1993). Gardner's *multiple intelligence theory* has influenced the learning styles approach (Allcock and Hulme, 2010).

Linguistic intelligence is defined as our ability to read, write, and communicate with words. Obviously, this ability is highly developed in authors, poets, novelists, copywriters, scriptwriters, orators, political leaders, editors, publicists, journalists, and speechwriters. People in this group are sensitive to patterns. They are orderly and systematic. They have ability to reason. They like to listen, read, and write.

Logical-mathematical intelligence is our ability to reason, calculate, and handle logical thinking. This is most developed in mathematicians, scientists, engineers, police investigators, lawyers, judges, and accountants. People in this group like abstract thinking and problem solving. They use logical structures and are precise. They enjoy counting and they are organised. Traditionally, most so-called intelligence tests have focused on linguistic and mathematical intelligence. And much schooling around the world concentrates on those two abilities. In accordance with Gardner, this has given us a warped and limited view of our learning potential.

Musical intelligence is the ability to compose songs, sing, and play instruments. People with musical intelligence are sensitive to pitch, rhythm, timbre, emotional power of music, and organisation of music. This is obviously highly developed in composers, conductors, performers, musical audiences, recording engineers, musical instruments makers, piano tuners, and also in cultures without traditional written language.

Spatial intelligence, or *visual intelligence,* is the ability to paint, take great photographs, and create sculptures. People with visual intelligence create mental images, use metaphors, and have a sense of gestalt. They like to engage in drawing, painting, and sculpting. These people can easily read maps, charts, and diagrams. This is the kind of ability used by architects, sculptors, painters, navigators, chess players, naturalists, and pilots.

Kinaesthetic intelligence, or *physical intelligence,* is the ability to use one's hands or body. A person in this category has exceptional control of his or her body, control of objects, good timing, trained responses, and good reflexes. He or she learns best by moving around and participating, and remembers what was done rather than what was said or observed. Kinaesthetic intelligence is highly developed in dancers, actors, athletes and sporting achievers, inventors, mimics, surgeons, karate teachers, racing car drivers, outdoor workers, and mechanically gifted *people.*

Interpersonal intelligence, or *social intelligence,* is the ability to relate to others. This is the kind of ability that seems natural with salesmen, motivators and negotiators.

Intrapersonal intelligence or introspective intelligence is the ability of insight, to know oneself – the kind of ability that gives some people great intuition. This is the kind of ability that lets you tap into the tremendous bank of information stored in your subconscious mind.

Cognitive learning

There are several learning models that belong to the group of cognitive learning. Bloom et al. (1956) have three levels in the cognitive domain: 1) Analysis,2) Synthesis, and 3) Evaluation. However, later Bloom (1964) discussed the following six levels:

1. Knowledge and simple facts.
2. Comprehension, understanding the importance of simple facts.
3. Application, knowing how to apply facts to a practical situation.
4. Analysis, knowledge gained from breaking the whole in parts.
5. Synthesis, knowledge of how to assemble ideas and facts to create a complete product.
6. Evaluation, knowledge of how to evaluate knowledge on the above levels.

Kintsch (1974) identified three major stages of cognitive learning:

1. The reception of information.
2. The transformation of the information into symbolic code.
3. The storage of information for later retrieval.

According to Heinich et al. (1982) the cognitive domain is based on a progression from simple to complex mental performance. They noted four levels:

1. *Knowledge:* recalling specifics, remembering, defining, recognising, and repeating.
2. *Comprehension:* translating, interpreting, paraphrasing, summarising, and extrapolating.

3. *Application:* using ideas and information.
4. *Creation:* combining components to form results.

Locatis and Atkinson (1984) summarise the principles of cognitive learning in the following three areas: 1) concept learning, 2) principle learning, and 3) problem solving.

1. Concept learning

- Determine whether to present a definition.
- Present very clear, unambiguous examples of objects belonging to the concept class, and indicate the class name.
- Present examples that clearly are not of the concept class but potentially may be confused as class members.
- Provide practice/feedback in discriminating between positive and negative examples.
- Provide practice/feedback in distinguishing between more ambiguous positive and negative examples, depending on the degree of discrimination required.

2. Principle learning

- Ensure that students have learned prerequisite concepts.
- Indicate the relationships among concepts.
- Demonstrate, or have students demonstrate, the principle.
- Provide practice and feedback in demonstrating the principle.

3. Problem solving

- Ensure that students have learned prerequisite concepts and principles.
- Present the problem.
- Provide direction and guidance.

- Provide problem-solving practice/feedback.

Tennyson (1994) distinguished between three kinds of knowledge resulting from cognitive learning:

- Declarative knowledge (knowing that…).
- Procedural knowledge (knowing how to…).
- Contextual knowledge (knowing the conditions: why, when, and where).

Ault (1985) discussed concept mapping. Learning includes the integration of new concepts into existing memory. Concepts that are more concrete are easier to integrate. Thus instruction must begin by presenting concrete images and concepts to the learners. Once these concrete concepts are established in the learner's memory, additional concepts can be attached, or mapped onto the new concrete concepts. The result is a series of concepts which are mapped together on an outward flowing continuum of concrete to abstract concepts and which are successfully integrated into pre-existing memory.

Another cognitive processing model is generative learning (Wittrock, 1974, 1989). The learner generates relations 1) between the text and the learner's knowledge and memories and experiences, and 2) between the units of the text, such as words, sentences, and paragraphs (Peled & Wittrock, 1990). The basic premise of generative learning is that learners will more easily recall images and concepts that they themselves generate as opposed to images and concepts generated by the instructor or generated by the learning material. According to Mattsson (1995) generative learning is expanded learning that bursts the existing knowledge frames. This learning is constructive and built upon mutual action between assimilation and accommodation processes (p. 215):

> To be able to retain existing schemata, repetition and smaller adjustment is needed, and to change schemata, renewal and development are needed. The balance between reproductive and productive learning is essential for human psychological well being. Different kinds of new sensory sensations or data must be quickly handled through accommodation processes so that data can be assimilated and become routine.

Mattsson (1995) found that generative learning is unbounded, and it allows individuals, groups and organizations to augment innovative knowledge.

Phenomenography is a method to investigate and describe the existing qualitative variation in how people experience different phenomena in the world around them (Marton, 1981). The object of investigation is the variation in which people experience, understand, see, conceptualize, or relate to different phenomena (Ottosson & Åberg-Bengtsson, 1995). Only a limited number of qualitatively different ways in which a phenomenon is understood can be found, ranging from very general to very specific. From a phenomenographic perspective learning can be regarded as a conceptual change, or a leap from a lower to a hierarchically higher conception. The focus is on the learner. The outcome of the learning process is analyzed in qualitative terms.

Perceptual learning

Since the brain is not fully developed at birth, it was once thought that infants could neither learn nor remember. In accordance with Atkinson et al. (1990), a large body of research has demonstrated that this is not the case. Very young children tend to react to situations as a whole. For example, when a baby tastes something objectionable, the whole body tends to respond, not just the taste organs. Through experience, children start differentiating their responses to the environment. Early learning experience of a child is through tactile and visual awareness. In addition, recognition includes smelling, hearing, and tasting in a rich, immediate environment. However, these senses are quickly distanced by the ability to see, recognise, understand, and remember visual impressions.

Children learn to perceive the world around them. There are two perceptual learning theories: the discovery theory and the enrichment theory. In accordance with the discovery theory, perceptual learning makes a person aware of stimuli he or she had previously not considered or overlooked. In laboratory settings, subjects have improved their abilities to perform auditory, olfactory, and visual acuity tests. Perceptual abilities are modifiable by learning. An active, exploratory interaction with the environment greatly enhances our perceptual learning. The enrichment theory refers to our increased awareness and heightened response capabilities, as a result of perceptual learning. A practical example of this is that we learn to assume that a plate remains circular even though it may appear elliptical when we view it from most angles.

Aha! learning

Learning is an active process. Just sitting passively and receiving information is not a particularly effective learning method. "Aha! learning" explains how understanding is developed from pieces of information that serve as cues. It focuses on compre-

hension and understanding based on insight. People acquire several little pieces of information until they see the whole – the “aha” experience. It must never be assumed that disseminated information is the same as received information. In language teaching, it has been found that a foreign word has to be repeated an average of 34 times before it has been learned.
An old teaching principle states that you should first tell your students what you plan to tell them. You then tell them what you wanted to tell them. Afterwards, you tell them what you have just told them. An old Chinese proverb states the following:

> That which I hear, I forget.
> That which I see, I remember.
> That which I do, I understand.

These old observations from reality have been confirmed by a number of different studies. We now know with great certainty that representations, such as text and pictures, sound and pictures, or sound, text, and pictures with redundant or relevant relationship provide the basis for much better learning than sound, text, or pictures alone. We also know that representations with irrelevant or contradictory commentaries result in poorer learning than sound, text, or pictures alone.

According to Cotton (1995) learning by doing was called the heuristic approach and it was summed up as the following in the mid-1950s:

> I see – I forget.
> I hear – I remember.
> I do – I understand.

Ellington and Race (1993) discussed learning by doing. They argued that (p. 63) doing is important:

> Most learning happens when we actually try to do something. Learning doesn't happen efficiently when we merely read about something or listen to someone talk about it. The measure of a good open learning package is what the students do as they work through it. Therefore, preparing to put together an open learning package (or adopting something which exists already) is not so much a matter of collecting together all the things students need to read – it's about collecting together a set of things to do.

Gestalt psychologists believe that conscious experience must be viewed as a "whole," and cannot be analysed into its parts. This "whole," or "gestalt," can be an image, a shape, or a thought. Seeing, hearing, and feeling must be studied together in order to understand their relationships. The Gestalt theory views learning as a process involving the attempt to think things out, to structure experiences, and then having "it all come together" in the mind. Sometimes, this is referred to as the "Aha! theory of learning," or the "insight theory." The Gestalt psychologists looked beyond behaviour and the environment.

Köhler, one of the early Gestalt psychologists, carefully studied a small number of chimpanzees at Tenerife. One chimpanzee managed to put two bamboos sticks together, and got a banana from outside the cage. Köhler drew the conclusion that learning takes place through an act of insight. The learner or problem solver must be familiar with the elements that constitute the problem and its solution, and the overall situation must be possible to survey. The learner seems to mentally manipulate these meaningful elements until, suddenly, a mental connection is made. We respond to meanings; we make intellectual connections. According to Carlson (1993) insight may be based on combinations of behaviours initially learned through trial and error.

Dewey accepted that the human abilities to think and to learn, had evolved as had all the other capacities of living organisms. He believed that intelligence is creative and flexible. Dewey developed a *problem solving theory* of learning. He stressed the link between learning and doing. Learning comes about as a result of our doing and experiencing, as we successfully solve real and meaningful problems. There is a clear difference between learning to do something and learning by doing. Learning a skill is acquiring the knowledge, perception and physical movements to be able to carry out a skilled performance. Learning by doing is a common teaching and learning method: active learning is an essential part of student-centred learning, work-based learning, competency-based learning, and experiential learning.

The learning hierarchy

Based on research on learning Bjørgen has defined a learning hierarchy (Kristiansen et al., 1994). This learning hierarchy include the following top-down levels:

- Independent creative work in the field of art, science and handicrafts.
- Self-employment, research.
- Studies and training, training on-the-job.
- Learning at school, instruction in hospitals and military service.
- The forming of behaviour, shaping, programmed learning

- Classical conditioning, habituation.

Bjørgen illustrates his learning hierarchy by using an up-side-down pyramid (the learning pyramid) where each level represents increasing learning competence and freedom of choice. The principles of development in this hierarchy are open to discussion. It is not a biological developmental model of stages, rather the opposite since the most developed level can be illustrated using pre-school age children. It is “natural” for children to learn.

As we move up the hierarchy we see increasing possibility for self- controlled learning with an increasing competence in taking responsibility for one’s own learning. In practice this will be determined somewhat by the situation and the context. In this hierarchical model the learning that is taking place in the school situation is placed somewhere in the middle. Bjørgen has introduced the two concepts truncated learning and intact learning (Kristiansen et al., 1994). Truncated learning consists of the following five steps:

1. The teacher gives a problem to the learner.
2. The learner accepts the problem provisionally.
3. The learner works for grading and examination.
4. The learning material is structured.
5. The learning process is terminated by the examination.

And intact learning consists of the following five steps:

1. The learner discovers a problem in real life.
2. The learner takes the situation seriously and accepts the problem.
3. The learner works realistically for the real life.

4. The learner brings his or her own experiences into the learning process.
5. The learner experiments and puts the new knowledge into practical use.

Social learning

The *social-learning theory* is concerned with human social interaction. It has its origin in behaviouristic studies of animal learning. Already the Soviet psychologist Lev Vygotsky (1896 – 1934) stressed that much of what we learn we learn from others in a social setting. Vygotsky (1962) asserted that thought development in children is sequential and dependent upon language development. The social-learning theory focuses on the behaviour patterns that people develop in response to their specific environments. Learning is historically and socially defined. Learning is not simply about discovery, nor about passive reception of ideas. Learning resulting from direct experience occurs on a vicarious basis by observing other people's behaviour and its consequences for them. The "zone of proximal development" is "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p. 86).

Vygotsky's theory was an attempt to explain consciousness as the end product of socialisation. For example, in the learning of language, our first utterances with peers or adults is for the purpose of communication but once mastered they become internalized and allow "inner speech." Vygotsky's theory is complementary to the work of Bandura on social learning and a key component of the *situated learning theory*.

Humanism is based upon the philosophy of Jean-Jacques Rousseau (1712 – 1778) who saw humans in the natural state as "noble savages" growing in isolation in a state of nature. According to Rousseau society perverts men and makes them ignoble. But nature also means a social life. The consequences have been a reduced emphasis on knowing and a greater emphasis on acting and doing, a promotion of positive interests in learning, and an encouragement of the child to depend on his or her own resources. Some theoreticians emphasise the role that social processes play in heightening insight, understanding, and conceptual thinking. It appears that people develop their capacity for thinking in the mutual exchange of ideas with other people.

Bloom (1964) noted five levels of the affective domain. These levels are:

1. Receiving: young students pay attention only to what is being said and carry out what they are told to do.
2. Responding: actively participating, reacting.
3. Valuing: take sides and defend work.
4. Organization: rationalize and judge by professional standards.
5. Characterization: demonstrating an internally consistent value system.

According to Heinich, Molenda and Rusell (1982) the affective domain is organised in accordance with the degree of internalisation, the degree to which the attitude or value has become a part of the individual. Heinich et al. noted four levels in the affective domain:

1. *Receiving:* being aware of and willing to pay attention to stimulus (listen or look).
2. *Responding:* actively participating, reacting.
3. *Valuing:* voluntarily displaying of an attitude, showing an interest (after valuing, Krathwohl et al., 1964, have "conceptualizing organization").
4. *Characterization:* demonstrating an internally consistent value system.

It is more and more common in the newspapers and business magazines that industry analysts state that knowledge is the most important production factor. The transition to global markets has caused difficult adjustment problems, as well as development problems, at both organizational, and enterprise levels. The rapid changing economical, technological, social and political conditions have upset previous stable business ideas as well as stable operational ideas. It is, however, not enough to possess the right knowledge.

This section includes five subsections: 1) Vicarious learning, 2) Collective learning, 3) Situated learning, 4) Experiential learning, and 5) Cognitive apprenticeship.

Vicarious learning

Some theoreticians emphasise the role that social processes play in heightening insight, understanding, and conceptual thinking. It appears that people develop their capacity for thinking in the mutual exchange of ideas with other people. The *social learning theory* of Bandura (1977) emphasised the importance of observing and modelling the behaviours, attitudes, and emotional reactions of others. Bandura noted the importance of human social interaction (p. 12): "Virtually all learning phenomena resulting from direct experience occur on a vicarious basis by observing other people's behavior and its consequences for them."

Social learning theory explains human behaviour in terms of continuous reciprocal interaction between cognitive, behavioural, an environmental influences. Bandura (1977, p. 22) stated:

> Learning would be exceedingly laborious, not to mention hazardous, if people had to rely solely on the effects of their own actions to inform them what to do. Fortunately, most human behavior is learned observationally through modeling: from observing others one forms an idea of how new behaviors are performed, and on later occasions this coded information serves as a guide for action.

Since people can represent situations symbolically, they are able to foresee the probable consequences of their actions and to alter their behaviour accordingly. We learn behaviour by merely observing what other people do and how they behave in different situations. The social-learning theory stresses the importance of vicarious learning or observational learning and we observe them getting rewards for engaging in that specific behaviour.

The social learning emphasises the role of models. Quite often, members of groups of people adopt the same attitudes, feelings, and emotions. Models may be "real" people, but they may also be persons in movies and in television programmes. The most common examples of social learning situations may be television commercials. Commercials suggest that drinking a certain beverage or using a particular hair shampoo will make us popular and win the admiration of attractive people. Depending upon the component processes involved (such as attention or motivation), we may model the behaviour shown in the commercial and buy the product being advertised.

A growing number of business experts are beginning to question the saying that "experience is the best teacher." According to leaders in the insurance industry, learning through trial and error is too expensive for them (Robert, 1993). Most successful managers agree that it is easier for people to learn from other people's experiences and mistakes. Mentoring is an important way of building on the collective knowledge of past generations.

We may see the *connectivism learning theory* as a modern version of Bandura's social learning theory. The connectivism learning theory emphasizes the role of social and cultural context within a digital infrastructure, a network with nodes and connections (Siemens, 2004). A node is anything that can be connected to another node, such as information, an organization, or a person. The learner builds knowledge via connections within a network. Connections or nodes can be resources or people. New information is continually being acquired. The ability to draw distinctions between important and unimportant information is vital.

Many of the learning theories discard the fact that learners almost always belong to various social groups.

Collective learning

There are many situations where we learn from each other, and learn together in cooperative learning, or collective learning. It may be in our leisure hours, or at work. It may be a group of people attending a meeting, or people working together on an assignment. It is possible to optimise people's situations in groups and organisations, primarily by heightening all individuals' consciousness and deepening their insight into their own situations. The 1990s are sometimes being called the "decade of the individual." There is a new kind of respect for the individual; people, not institutions, are society's driving force.

Cooperative learning is a common classroom practice that enjoys considerable popularity in many schools (Johnson and Johnson, 1989; Sharan, 1980; and Slavin, 1989). Some educational guidelines encourage teachers to use cooperative learning and small-group techniques as a teaching approach (National Council of Teachers of Mathematics, 1989; Science for All Americans, 1989).

Cooperative learning has become an important area in educational technology and in instruction design. This is partly because students often must work together with a limited number of computers. However, studies conducted to examine the effect of implementing cooperative learning with computer-assisted instruction have provided mixed results. Some researchers have reported that student achievement increased when cooperative strategies were used (Dalton et al., 1989; Hooper, Temiyakarn & Williams, 1993; Johnson, Johnson & Stanne, 1985). However, Carrier and Sales (1987) did not find any significant effect for better achievement when learners used cooperative computer-assisted instruction.

Loop learning

Stockfelt (1987) noted that learning should not be concentrated to specific buildings, or to specific classrooms. In a learning organisation learning takes place at work. The learning processes are linked to the work processes. Any work place may also be a learning situation and any task may likewise be an exercise. The emphasis should be on learning together in teams. And not just within a division, a department or a group, and not only at one level, but also between departments, divisions, and groups and between the different levels in the organisation.

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According to Juechter (1993), the ability to learn faster and more efficiently than the competitor has become a new hallmark of a successful organisation. Gaining and keeping a competitive advantage nowadays depends on the knowledge that people possess and the work that their knowledge enables them to do. Learning is a business imperative. Reinhardt (1995) concluded that in the information economy, knowledge is power. However, traditional teaching is expensive and slow (Dryden & Vos, 1994; Robert, 1993; Reinhardt, 1995). New technologies may make learning more productive (Dwyer, 1993). According to Reinhardt centralized training in companies is now giving way to distributed just-in-time learning. The result is increased flexibility, better retention, and lowered costs.

Mellander (1993) stated that the management style of the 1990s is "management by learning." The boss is expected to train and learn together with his or her subordinates, and thus to share leadership responsibilities with them. Here, the Japanese concept of continuous improvement (kaizen) may be a crucial factor. Imai (1986) calls kaizen the single most important concept in Japanese management. Kaizen is the key to Japanese competitive success. Imai defined kaizen in this way (p. xxix):

> KAIZEN means ongoing improvement involving everyone – top management, managers, and workers. In Japan, many systems have been developed to make management and workers KAIZEN-conscious.
>
> KAIZEN is everybody's business. The KAIZEN concept is crucial to understanding the differences between Japanese and Western approaches to management. If asked to name the most important difference between Japanese and Western management concepts, I would unhesitatingly say, "Japanese KAIZEN and its process-oriented way of thinking versus the West's innovation- and results-oriented thinking.
>
> ... In business, the concept of KAIZEN is so deeply ingrained in the minds of both managers and workers that they often do not even realize that they are thinking KAIZEN.

Leymann and Gustavsson (1990) pointed out that group-dynamic learning in organisations could be both positive and negative. It is important to create working environments that are conducive to learning and assignments that give the individual the opportunity to develop his or her learning capacity. Leontjew (1982) claimed that the tools that are used primarily affect the situation in the workplace. The transfer of competence occurs as a result of the interaction between people. Ekman (1998) studied the correlation between manufacturing efficiency and operator competence in advanced manufacturing technology in mechanical engineering companies. He concluded that increased investments in education and competence development did not result in increased operator efficiency.

Learning is still learning, even if it results in something unfortunate, useless, or damaging. In mass media prisons are sometimes called "universities of crime" where prisoners learn how to perform different kinds of crimes.

According to Leymann and Gustavsson (1990) the North American view holds that people must be offered some form of satisfaction, regardless of whether it is material or psychological. Collective decisions regarding staff participation in corporate processes or democracy in the company are not as important. Similarly, power-sharing – in which employees are expected to participate in making decisions – is something that employees do not take seriously. In my view these statements are far too broad and definitive.

Judgment and decision-making

Daniel Kahneman is notable for his work on the psychology of judgment and decision-making, behavioural economics and hedonic psychology. In 2002 he and Vernon L. Smith shared the 2002 Nobel Memorial Prize in Economic Sciences. Kahneman was heavily influenced by research made by psychology professors Keith Stanovich and Richard West. Stanovich and West were some of the first to thoroughly examine differences within people's rational thinking and they found that many didn't make ideal choices. Kahneman (2011, p. 27) adopted the idea of *two mental systems*, which he called System 1, and System 2.

System 1 (or *Intuition*) is automatic, fast, implicit, and based on unconscious reasoning. System 1 requires low effort and has a large capacity. It is nonverbal and includes associations, orientation, perception, and recognition. System 1 is very difficult to change or manipulate.

System 2 (or *Reasoning*) is controlled, explicit, slow, and based on conscious reasoning. System 2 requires high effort and has a small capacity. It is abstract and linked to language. It includes comparisons, conscious judgments, following of rules, and weighing of options.

The TVI-method

The further education programme at the Norwegian University of Technology in Trondheim has been very successful. Based on experiences from the TVI-method, *Tutored Video Instruction*, that was developed more than twenty years ago at Stanford University, a method of team learning supported by media has been developed.

The TVI-method is based on the common-sense notion that students can learn more from a lecture if they are free to interrupt it at places where they need more discussion or explanation of a point or a concept (Gibbons et al., 1977). The TVI-method supports the communication processes by providing a tutor who acts as a catalyst between the individual learners. In various workplaces in Norway, groups of people engage in this distance education programme. Each team receives videocassettes with recordings from ordinary lectures in the university courses. The members of the teams view these recordings, and interact in various group discussions and group activities. People are active and motivated to learn.

Hebnes (1995) reported that 90% of the members in three teams (30 persons) preferred this kind of media-supported team learning compared with traditional lectures. It was claimed that the factor of success is not the video as such, but the group interaction. The TVI-method has been extended into a TMI-method, Tutored Media Instruction, making use of other instructional media such as computer aided instruction and multimedia. The TMI-model provides a very flexible framework for the use of instructional media. It can be adapted towards regional, institutional, content specific, and above all it can be adapted to learner specific needs, individual learning experiences and learning styles, previous knowledge, and different cultural backgrounds.

Meta-learning

Mattsson (1995) concluded that it is important to create environments that give employees possibilities to learn by being stimulated as well as allowing for the construction of individual and collective knowledge. In a context of knowledge-intensive industry that is changing continuously, individual and organisational routines are needed to handle both cognitive and organisational imbalance and dramatic changes. When looking only at concrete contextual work, problems often result in limited and shortsighted effects for learning instead of for drastic changes and improvements. Learning is put in focus, since people need to be able to handle changes.

Berg (1993) concluded that in the learning/modular/virtual/boundaryless/permanently flexible organizations that are being promoted as the best organisational structures for today's fast-changing environment, continuous learning is a critical variable for success. Companies that excel will be those that make full use of their staff's capacity to learn. In accordance with Berg (1993), the ideal employee is a person who loves learning, is flexible, acquires new skills as needed, and is confident enough to devise new rules when the old ones do not work any longer. This is certainly a kind of person with a high competence.

As a society, we place too much faith in collecting facts. Experience suggests that there should be a correct way to do everything; as a result, we waste a great deal of time, money, and energy searching for this mythical right answer. Gathering insight and experience is only helpful if it leads to constructive action. Berg (1993) provided eight steps that organizations and individuals can take to learn the lessons they will need for future success. These steps are:

- Assume nothing.
- Give up the search for right answers.
- Trash your taboos.
- Devote time to learning.
- Reward failure.
- Do not do more of what does not work.
- Do not put people into slots on an organisational chart.
- Reward contribution, not position, longevity, or status.

According to Berg, the future belongs to those who question the past assumptions, constantly innovate, and thrive on change.

Swieringa and Wierdsma (1992) concluded that, essentially, learning organisations are not only capable of learning, but also of learning to learn. Learning to learn is meta-learning. In other words, learning organisations are not only able to become competent but they are also able to remain competent. The basis for meta-learning is self-knowledge: in particular knowledge about how and why we are learning and why we wish to learn.

According to Swieringa and Wierdsma a learning organisation is based on a philosophy in which its members consider themselves and each other as people who have the will and the courage to take on responsibility for their own functioning in relation to other people, and expect the same from them.

Situated learning

Lave (1988) argued that learning normally is a function of the activity, context and culture in which it occurs. Learning is situated. Social interaction is a critical component of situated learning – learners become involved in a "community of practice." This contrasts with most classroom learning activities which involve knowledge which is abstract and out of context. In everyday situations, people reason intuitively, based upon their experiences within specific contexts, using a variety of methods to solve problems.

Situated learning can be defined as "the notion of learning knowledge and skills in a context that reflects the way the knowledge will be useful in real life" (Collins, 1988, p. 2). By creating meaning in context, learning becomes more realistic and a more meaningful process (Jonassen, 1991). According to Winn (1993), situated learning occurs when students work on authentic tasks, whose execution takes place in a real-world setting. The content of the knowledge that is constructed is defined by the environment where the learning occurs.

Situated learning has mainly been applied in the context of technology-based learning activities for schools that focus on problem-solving skills. During problem solving, knowledge acquisition or learning takes place. Thus, learning appears as an activity that indirectly permits the individual to satisfy fundamental needs and, in turn, to adapt to the environment. Since authentic tasks are often problem based, learners are better able to gauge what they are learning and how to use it (Collins, 1993). They learn, based on first-hand experience, when a particular method or strategy is appropriate in authentic contexts. Learners learn to respond to changes in circumstances that influence their own problem solving.

Brown, Collins, and Duguid (1989) found that knowledge would remain under construction in each new situation, each new experience, and each new activity. Memories often include the context in which the learning took place. When attempting to develop situated learning environments, instruction designers use media to provide rich contexts that reflect their interpretation of the real world. The act of observation intervenes and changes what is being observed. It is not possible to be an objective observer of reality, because our methods of observation interact with the process being observed. We cannot observe reality objectively because we participate in it. So, we cannot know exactly why people learn. We do not doubt that they do, only that we can control and predict the process with some degree of certainty.

Perkins (1985) noted that many students experience problems in utilizing the knowledge and the skills acquired via formal learning to their everyday contexts. Often the learning of facts is isolated from the contexts in which these facts actually derive their meaning. In formal education settings, such as traditional classrooms, skills and knowledge are operationalised differently from how they later may be used in one or more real life situations. Choi and Hannafin (1995) found that students may very well pass their exams but they are unable to apply the same knowledge in everyday life when they actually need the knowledge. Smith and Ragan (1999) pointed out that in situated learning testing should be integrated into the task, not a separate activity.

Experiential learning

The process of active learning and real work experience is sometimes called experiential learning. To Rogers (1969) experiential learning is equivalent to personal change and growth. The role of the teacher is to facilitate learning. Learning is facilitated when it primarily is based upon direct confrontation with practical, social, personal or research problems. Rogers noted that significant learning takes place when the subject matter is relevant to the personal interests of the student. He also noted that learning proceeds faster when the threat to the self is low.

One of the learning theories that have captured a lot of attention is Kolb's experiential learning theory (1984). According to Kolb, learning is based upon repeated interactions between different cognitive processes and our direct experiences. Kolb developed a model of the styles of learning that people employ when they approach new situations. The learning process is divided in the following four phases: 1) Concrete experience. 2) Reflective observation. 3) Abstract conceptualization. 4) Active experimentation.

These four phases are grounded on two dimensions, one is called the "active-reflective" axis, and the other is called the "concrete-abstract" axis. Later Kolb, Rubin and Osland (1991) discussed learning organisations and specified four steps, in their continuous development. Their four steps are: 1) reflecting, 2) thinking, 3) deciding, and 4) doing.

Reflecting is linked to a period of forming and reflecting on what has happened. Thinking is linked to education. Deciding is linked to consulting, and doing is linked to training.

Learning on demand is a concept for continuing technical education and training at your own workplace. Many large corporations use the public Internet or their own local Intranet as the distribution form, together with existing courses. Intranet is one of the fastest expanding areas in the computer industry. Large companies, like Microsoft, Netscape, Lotus and Sun are creating tools that can be used in a wide variety of new corporate applications, such as collaborative workgroups and intra-company communication.

Cognitive apprenticeship

Traditionally people have learned to speak, learned to use tools, and learned their crafts by observing and imitating their parents and their masters. When we watch someone carrying out a skill the performance appears to be automatic, confident, consistent, easy, effective, efficient, fast, and smooth. When problems arose in the everyday context of work, apprentices understood the reasons for the problems in a natural way. They asked the necessary questions, and imitated the observed steps to solve the problems. Apprentices acquired their skills through a combination of observation, coaching, and practice. This promoted development of mental models, scaffolding, and gradual self-reliance (Winn, 1993).

Today apprentice settings have been largely replaced by formal education. Now activities often focus on superficial aspects of complex problems. Too little attention is paid to the reasoning processes, and to the strategies that experts employ when they apply knowledge and perform complex and real-life tasks. In accordance with Collins et al. (1989), the cognitive apprenticeship model seeks to aid the learner in the construction of knowledge by embedding "the learning of skills and knowledge in their social and functional context" (p. 454). Brown, Collins and Duguid (1989) argued that cognitive apprenticeship supports learning in a domain by enabling students to acquire, develop and use cognitive tools in authentic domain activity. Learning, both outside and inside school, advances through collaborative social interaction and the social construction of knowledge.

Cognitive apprenticeship focuses specifically on cognitive and meta-cognitive skills. Media can function as powerful tools within a cognitive apprenticeship model, by facilitating the construction of knowledge through the provision of mediated contexts. These contexts may not be fully recreated, only simulated. Cognitive apprenticeship emphasizes relationships between the content knowledge and thought processes that experts employ when they perform complex tasks. According to Choi and Hannafin (1995) the "apprenticeship" concept emphasizes the importance of experiential activity in learning, and highlights the inherently context-dependent, situated, and acculturated nature of learning.

The cognitive approach challenges the traditional behaviourist assumption that behaviour can be understood by considering only external or environmental factors. In accordance with cognitivists, intelligence is the ability of an organism to mentally represent aspects of the world and then to operate on those mental representations rather than on the world itself. These mental operations are a kind of mental trial and error. Information is selected from the environment and placed in a temporary buffer, called working memory, and also short-term memory. Once selected, the information is subsequently either discarded or processed more completely. Encoding occurs when new and existing information is integrated in the working memory and then transferred into the long-term memory.

Knowledge

A number of theories describe the transfer of data and information into memory. Our memories make it possible to store experiences, recognize things, and learn. With the help of our memories we can think and tackle the problems that face us. Memories give us a place in the time dimension. Memories become a part of our personalities. However, whether memory is a basic source of knowledge or not is a controversial issue. According to Bernecker (2015) some philosophers maintain that memory only retains or preserves knowledge but doesn't produce new knowledge. Others, however, insist that there are cases where a person first comes to know by remembering.

Special kinds of knowledge may be said to un-consciously *reside in biological systems*, such as the DNA of the genetic code. Furthermore there are *divine expressions* of knowledge in many religions. For example in Catholicism religious knowledge is one of the seven gifts from the Holy Spirit. Religious knowledge is also given great significance in Islam. However, these aspects of knowledge are not discussed in this paper.

Approaches to knowledge

Memory and knowledge are not the same. Knowledge is about much more than memory, especially about *understanding*. From the literature one can easily get the impression that the academic and scientific interest in the concept *knowledge* has increased in recent years. Many authors have different opinions of what knowledge is and what it is not, and there are a number of alternative definitions and taxonomies.

To the Greek philosopher Plato (428–348 BC), knowledge was “a priori” in place in the mind already at birth. Learning was a process of recalling what the soul had already absorbed in an earlier life. To Plato, the pupil was a spectator of reality, and teaching was just helping of the remembering process. In order to be considered knowledge Plato argued that a statement must be: 1) justified, 2) true, and 3) believed. Some claim that these conditions are not sufficient.

The Greek philosopher and scientist Aristotle (384–322 BC) was a student of Plato. He insisted that perceptions and not ideas are the base for reality (Johannesson, 1999, p. 15). Also Aristotle described three approaches to knowledge: 1) Episteme, 2) Techné, and 3) Phronesis.

Episteme means scientific knowledge, “to know.” Aristotle's scientific knowledge is context-independent, invariable, and universal. It includes only what is absolutely necessary. These necessary conditions are eternal and immutable. The other two types of knowledge involve conditions that change over time. The Greeks viewed episteme as a partner to the second approach, techné.

Techné means “skills and crafts.” We can both learn and forget skills and crafts. To have such knowledge is to be able to do something meaningful on the basis of the circumstances with the resources actually at our disposal. We may have enough knowledge about something we need to do. However, we might not be able to actually do it. Aristotle viewed techné as an imperfect human representation of nature. Today the original concept techné appears in terms such as “technique” and “technology.”

Phronesis means “practical wisdom.” Practical wisdom means that we know which action is morally correct in a given situation. We can neither learn nor forget practical knowledge. Aristotle's concept of knowledge includes elements of good judgment as well as individual reflection. This is influenced by every specific and unique situation.

The Greek word *epistemology* aims to discover the meaning of knowledge. It is the branch of philosophy concerned with the nature and scope of knowledge, or a *theory of knowledge*. For our purpose in this paper *knowledge* refers to having awareness, facts, information, skills, and understanding of someone or something. Knowledge allows us to see new patterns, draw new conclusions and then create new knowledge. So far there is no consensus among those participating in this debate and there are numerous competing *theories of knowledge*. To some extent, the debate has focused on how the *theoretical knowledge traditions* stand in clear opposition to the *practical knowledge traditions*.

Theoretical knowledge traditions

A theoretical understanding of a subject is *explicit*. This section includes the following sub-sections: 1) Explicit knowledge. 2) Traditional academic view. 3) Pragmatic process-perspective. 4) The standpoint theory and situated knowledges. 5) Worlds of knowledge.

Explicit knowledge

Explicit knowledge, or *codified knowledge*, can be readily accessed, articulated, codified, and verbalized (Nonaka and Takeuchi, 1995). Many kinds of explicit knowledge can be stored in media and easily be transmitted to others. Good examples of explicit knowledge are data and information contained in encyclopedias and textbooks. Explicit knowledge resulting from cognitive learning can be of several forms, such as *declarative knowledge, procedural knowledge*, and *contextual knowledge*.

Declarative knowledge (knowing that...) is defined as the factual information stored in memory and known to be static in nature (Tennyson, 1994). Declarative knowledge is also called *descriptive knowledge* and *propositional knowledge*. Declarative knowledge is expressed in declarative sentences or indicative propositions and specifies what action to take when one is presented with a set of stimuli.

Procedural knowledge (knowing how to...) is the practical skills of *how* to perform a task (Tennyson, 1994). This "know-how"-type of knowledge is formed by doing and cannot be easily articulated by the individual. It permits a professional to determine which treatment or action is best, even in the presence of significant noise. Procedural knowledge is also called imperative knowledge and implicit knowledge.

Contextual knowledge (knowing the conditions: why, when, and where) means understanding of knowledge in its context (Tennyson, 1994). One example is how knowledge is situated in organisational contexts (Goldkuhl and Braf, 2001). This type of knowledge will usually involve an understanding of underlying theory and/or a range of experience of an area.

Nonaka and Takeuchi (1995) used the helix metaphor and proposed a *knowledge spiral* that aims to explain how individuals and groups convert knowledge from a tacit to an explicit form and vice-versa, and share both tacit and explicit knowledge. This model was subsequently further developed by Nonaka, Toyama and Nagata (2000). Here the helix reproduces an upward evolutionary path, with an unlimited continuity perspective, in which the reaction loops do not tend to close in the form of the classic feed-back but act as virtuous circles (Miron, 2008).

Traditional academic view

A traditional academic and theoretical view is that we can only have knowledge of things that we can demonstrate with empirical data, or about things that we can prove with formal methods and then articulate by verbal means, or in some other notational form. Here, writing and reading is seen as universal tools for the transfer of knowledge from one person to another.

These scientific traditions have developed prescriptive scientific methods on collection of data through experimentations and observations, and then processing of data in different systematic manners. However, the Austrian-born philosopher of science Paul Karl Feyerabend challenged the traditional scientific traditions when he was a professor of philosophy at the University of California, at Berkeley. Feyerabend (1975, 1978) argued that there are no methodological rules that scientists always use. Constant use of any single prescriptive scientific method would restrict scientific progress. In fact, such mandatory methodological rules would have prevented scientific progress in the past.

With a limited and restricted approach everything other than what is possible to describe with words, numbers and other characters will fall outside of the traditional academic area of knowledge. According to the *causal theory of knowledge* one's belief that things are in a certain way must be caused by things' actually being in a certain way (Goldman, 1967).

Pragmatic process-perspective

The Norwegian philosopher Kjell Sander Johannessen, a professor of philosophy at the University of Bergen, has worked with the philosophy of language and the theory of art. Johannesson (1990a) discussed four different aspects of knowledge. It is the pragmatic process-perspective: 1) propositional knowledge, 2) competence knowledge, 3) familiarity-knowledge, and 4) the judicious aspect.

Propositional knowledge is expressed by some kind of linguistic means in declarative sentences or indicative propositions. It can be formulated in terms of principles, rules and theories. The character of factual knowledge makes it possible to use exact wordings. It is, however, not the only type of knowledge that is scientifically relevant. Propositional knowledge is also called *declarative knowledge* and *descriptive knowledge*.

Competence knowledge means that a person has rehearsed and master practical skills. This is the "skill aspect" of knowledge. *Procedural knowledge* is the knowledge of *how* to perform a task. These practical skills are expressed in a safe touch when a task is to be performed.

Familiarity-knowledge, or the *familiarity aspect of knowledge*, cannot be formulated as rules and it cannot be expressed in any exact way.

The judicious aspect of our practically acquired conceptual hold on reality can be seen as a result of a fusion, or a synthesis, of the other three aspects of knowledge. The judicious aspect includes the establishing, application and mediation of knowledge.

Situated knowledges

According to the *standpoint theory* authority is rooted in all individuals' private knowledge (Harding, 1986). Standpoint theory is a feminist and postmodern method for analyzing intersubjective discourses. Personal political and social experiences regulate and shape the knowledge of individuals. Knowledge can include descriptions, facts, information, and skills acquired through education or experience. Here scholars have focused particular attention on gender and marginalized groups. Feminine viewpoints shape women's communication and can create more objective views of the world. The white male-dominated and privileged world is complicated to understand and to challenge. The ruling groups dominate society and suppress opinions in subordinate groups.

Based on feminist studies and post-structuralism Haraway (1998) developed the concept of *situated knowledges* in response to the *standpoint theory*. In post-structuralism the author's intended meaning is secondary to the meaning that the reader perceives. Knowledge that is specific to a particular situation is called *situated knowledges*.

Haraway noted (1998, p. 580): "we do need an earth-wide network of connections, including the ability partially to translate knowledge among very different–and power-differentiated–communities." Coming to terms with the agency of the "objects" studied is the only way to avoid gross error and false knowledge.

Situated knowledges is the only kind of knowledge there is, and it will always be partial (Griffin, 2009). It is a form of objectivity related to science studies, which is supposed to offer a better account of the world. Knowledge is often embedded in culture, language, and traditions. People from lower status communities "experience" more and have a more complete and diverse knowledge of the world.

The *standpoint theory* and *situated knowledges* both continue to inform discourse in education theory, feminism, and science.

Worlds of knowledge

According to the scientist Rolf Lövgren (2007) the foundation for knowledge is communication. Knowledge is a man-made concept. It relies on mutual understanding of at least two human beings. Knowledge comes from data interpreted by humans for answering human questions for the use of humans. Mutual understanding among people (in principle the more the better) is essential for establishing more robust knowledge, which the methods of the scientific world exemplify!

As an alternative to the concepts “theoretical knowledge” and “practical knowledge” Lövgren (2007) defined two types of “knowledge worlds.” These knowledge worlds are called: 1) abstract worlds of knowledge, and 2) concrete worlds of knowledge.

An *abstract world of knowledge*, e.g. mathematics and theoretical philosophy, has an absolute existence. It is self-contextual, and it is time independent. It is eternal.

A *concrete world of knowledge*, e.g. aesthetics and biology, has a relative existence. It is always contextual in space and in time, and it is time dependent. Here knowledge must correspond to phenomena in the concrete world. We may see this knowledge as ongoing current interpretations.

Practical knowledge traditions

Practical expertise or skills are typically *implicit*. This section includes the following sub-sections: 1) Tacit knowledge. 2) Implicit knowledge. 3) Different interpretations. 4) Long life experience. 5) Organisational knowledge.

Tacit knowledge

Michael Polanyi (1891–1976) was a Hungarian-British scholar, who made important theoretical contributions to chemistry, economics, and philosophy. Polanyi (1946) argued that a positivist account of science supplies a false account of knowing. He found that it ignores the role personal commitments play in the practice of science. Polanyi (1958) argued that all knowledge claims rely on personal judgements. All knowing relies upon commitments. Our tacit awareness connects us with reality. He introduced the term "tacit knowing" or "tacit knowledge."

In his book *The Tacit Dimension* (1966) Polanyi distinguished between the instrumental, ontological, phenomenological, and semantic aspects of "tacit knowing/tacit knowledge." Already at the beginning of the book Polanyi noted the following (p. 4): "we can know more than we can tell." It is obvious that we take many perceptions, sensations, social rules and values for granted when it comes to human behaviour. The key to acquiring tacit knowledge is *experience*. Once we have learned how to use various tools we don't have to think about it any more. Knowing the explicit knowledge, however, is no real help in using a hammer.

Michael Polanyi argued that tacit knowledge plays an important role in both practical as well as theoretical knowledge, although it is not possible to give it an explicit formulation. Polanyi wanted to show that even nationalist and positivist theory of knowledge must rely on human and social processes that are not fully understood or even examined critically in a scientific way.

Polanyi's "concept tacit knowledge" is based on knowledge of philosophy and social philosophy. But the "term tacit knowledge" has sometimes been associated with the Austrian-British philosopher Ludwig Wittgenstein (1889-1951) and his work with *philosophy of language*. Wittgenstein was professor of philosophy at the University of Cambridge. Philosophy of language is concerned with four central problems: 1) the nature of meaning, 2) language use, 3) language cognition, and 4) the relationship between language and reality.

Polanyi and Wittgenstein agreed that there is always knowledge that is not formulated in a linguistic way with the help of words. Wittgenstein argued that there is knowledge which by its nature is somewhere beyond the limits of language. However, for Polanyi it was not certain that it is not possible to describe all kinds of knowledge with verbal language. The fact that we do not express some knowledge verbally does not actually mean that it is not possible to do so.

As previously noted Johannessen (1990a) observed that *propositional knowledge* is not the only type of knowledge that is scientifically relevant. Some scholars have accepted that it might be legitimate to talk about knowledge also in cases where it is not possible to articulate it in full measure by proper linguistic means. Using Polanyi's terminology Johannessen called the kind of knowledge that cannot be fully articulated by verbal means for *tacit knowledge*.

The concept "tacit knowledge" is nowadays used in many areas and in many situations such as: artificial intelligence, business, care, education, healthcare, industrial production, innovation, management, and organizational learning. Göranzon and Josefson (1988) edited a book about artificial intelligence, knowledge, and skills. Engel (2008) investigated tacit knowledge and implications for medical education. Depending on one's interpretation of Polanyi's (1966) definition) tacit knowledge is either impossible, or difficult, to articulate.

Implicit knowledge

As previously noted practical expertise or skills are typically *implicit*. *Implicit learning* is the learning of complex information in an incidental manner, without awareness of what has been learned. Implicit knowledge is knowledge that is not explicit like tacit knowledge. It has not yet been codified, while tacit knowledge may well be impossible to codify. Implicit knowledge is somewhere between explicit knowledge and tacit knowledge.

Competence knowledge means that a person has rehearsed and master practical skills. This is the "skill aspect" of knowledge. Competence is the strategy a professional would apply in practice if given the opportunity.

Different interpretations

There are different interpretations of Polanyi's concept of tacit knowledge. In 1991 the philosopher Harald Grimen discussed three interpretations (Yu, 2006). One interpretation was called "the Gestalt thesis of tacit knowledge."

When one person is engaged in a certain activity, such as riding a bicycle, that person has to rely on an unarticulated background. In the process of performance the agent himself cannot articulate an unarticulated background.

Another interpretation is called "the thesis of epistemic regionalism." At any given moment, one person can only reflect on small parts of the knowledge system and verbally articulate them. It is not possible to verbally articulate all that we know.

A third interpretation is called "the strong thesis of tacit knowledge." Some specific kinds of knowledge are, in principle, not possible to articulate verbally. In such cases there exists a logical gap between our capacity of cognition on the one hand, and our capacity of verbal articulation on the other.

According to Grimen (Yu, 2006) the knowledge that we in principle cannot articulate verbally is *tacit knowledge*. It can be accumulated, criticized, learned, and transferred. However, the modes of accumulating, articulating, criticizing, learning, and transferring tacit knowledge are different from the modes of verbally articulated knowledge.

Professor Bertil Rolf (1991) made a careful analysis of Polanyi's ideas about "tacit knowledge." In addition to the categories "the understood" and "the misunderstood" there is also the category "the implied." Even the word "knowledge" itself has different connotations and can be perceived in different ways by different people. The author noted that the German expression "implizites Wissen" better matches the original spirit of Polanyi's text. Rolf discussed three categories: 1) emergence of knowledge (how we learn something), 2) content of knowledge (what we know now) and 3) function of knowledge (what we use knowledge for). Rolf noted that Polanyi's theory of tacit knowledge involves the function of knowledge. This function is expressed in a person's ability to use her or his own knowledge in any specific action, or the ability to acquire new knowledge when necessary. So we do not always articulate our knowledge in words.

Transitive verbs are action verbs that require a direct object. The verb's action is transferred directly to the object, which can be a noun, pronoun, phrase, or clause. Intransitive verbs don't require a direct object. According to Johannessen (1990b) *intransitive understanding* is autonomous. It does not relate to anything else and it is a global phenomenon. *Transitive understanding* on the other hand can be translated into other media of expression. In intransitive understanding a work of art is grasped individually as an entirety, and a particular kind of experience that involves a feeling of familiarity.

Today, perhaps we can say that tacit knowledge refers to the practical experience, the familiarity and expertise and the practical know-how that is gathered by groups of professionals, i.e. knowledge of how to do anything. We can recognize things and we can do things without being able to verbalize and explain how we recognize something or exactly how or why we are actually doing something in a certain way.

Long life experience

We acquire our tacit knowledge gradually through practice and long life experience. We cannot formulate and transmit tacit knowledge in a complete and traditional way by using words and images in fiction books, in textbooks or in other media. Two typical examples of tacit knowledge are: 1) "to (be able to) ride a bicycle," and 2) "to (be able to) recognize a face" (Molander, 1996, p. 41).

No one can give a full description and provide complete instructions on how to ride a bicycle so that another person can read it, and immediately be able to ride the bicycle without any problems in the traffic. It is obvious that many people learn to ride a bicycle without the ability to explain exactly what is happening and why it occurs. The same applies when we recognize a face. At the beginning of his book *The Tacit Dimension* Michael Polanyi noted (p. 4): "We know a person's face, and can recognize it among a thousand, indeed among a million. Yet we usually cannot tell how we recognize a face we know. So most of this knowledge cannot be put into words." A few other examples of activities based on tacit knowledge are: boiling an egg, driving a car, hitting a nail with a hammer, making a cup of coffee, and playing the piano.

It is easy for an experienced biologist to recognize an animal or a plant species based on general appearances. A great tit always looks like a great tit, and never like a goshawk or a magpie. Similarly, newspaper readers know the look of their daily newspapers, despite the fact that the actual content, of course, varies from day to day. We can easily see if there is a significant change in the design. This reasoning would largely apply to images that we use in information materials and in teaching aids. With the help of pictures and movies, we can learn how animals in foreign countries look like and how they live, even if we never get the opportunity to see them in real life. But so far a film or a video cannot completely replace a real experience.

Molander (1993, p. 54) argued that tacit knowledge covers areas such as attention, experience, familiarity, judgment, personal commitment, security, skills, talent, and understanding. Much of this is within the individual's own habitat. The craftsman's or the expert's knowledge is a living part of the person (Molander, 1993, p. 229). The emphasis is however on their own action, attention, and understanding. We must therefore trust our own knowledge and our own skills, but we also need to be aware and know our own limits. It is necessary to be able to shift perspective–this is a matter of attention, ethics, and insight.

Organisational knowledge

When individuals pool all their individual knowledge within an organization, that *organizational knowledge* can give an advantage over others working in the same field. Organizational knowledge exists in the form of routines resulting from an accumulation of past experience that guide future behaviour.

In organizational knowledge many authors refer to the philosopher Michael Polanyi. Haldin-Herrgård (2000) recognised difficulties in diffusion of tacit knowledge in organizations. Lam (2000) studied organizational learning and tacit knowledge in societal institutions. Grensjö (2003) discussed education in the workplace. In addition to tacit knowledge Grensjö also discussed silencing and *silenced knowledge* related to democracy and power. Irick (2007) discussed tacit knowledge in business from a management perspective.

Nonaka and Takeuchi (1995, p. 59) pointed out that tacit knowledge is personal, context-specific, and difficult to formalize and to communicate to others. It is highly rooted in action and experience. Tacit knowledge can be restricted to just one individual, or be shared within a group of people. Much of what constitutes excellence in organizations is tacit knowledge that can only be passed on through personal interaction between employees in social networks in the organizations. Nonaka and Konno (1998) studied how to advance collective and individual knowledge in physical and virtual environments.

Metaknowledge, or *meta-knowledge*, is knowledge about knowledge. Bibliographic data are considered as a metaknowledge. This is important in knowledge engineering and knowledge management. *Knowledge engineering* is the scientific, social, and technical aspects involved in building, maintaining and using knowledge-based systems. *Knowledge management* is the process of capturing, developing, effectively using, and sharing organizational knowledge (Nonaka, 1991).

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