DOCUMENT RESUME

ED 391 522 IR 017 675

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TITLE	The Learning Helix.
PUB DATE	[95]
NOTE	14p.; In: Eyes on the Future: Converging Images, Ideas, and Instruction. Selected Readings from the Annual Conference of the International Visual Literacy Association (27th, Chicago, IL, October 18-22, 1995); see IR 017 629.
PUB TYPE	Reports - Evaluative/Feasibility (142) -- Speeches/Conference Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Attention; Audience Response; *Cognitive Processes; *Information Processing; *Learning Processes; Long Term Memory; Models; Short Term Memory; *Visual Perception; Visual Stimuli

ABSTRACT

This paper discusses a mental model of learning based on the processes of attention, perception, processing, and application. The learning process starts with attention, such as curiosity, excitement, expectation, or fear; in pedagogy this is called motivation. New impressions are dependent on and interpreted against the background of previous experience and learning, or "frame of reference." One of the main reasons for using pictures in magazines, newspapers, and books is to draw attention to the material; in the case of moving images, the visual material and presentation must constantly redraw the attention to hold the viewer's interest. The concept "perception" is a collective designation for the processes in which an individual obtains information on the outside world. The "laws" of perception include: figure/ground contrast; similarity; proximity; continuity; closure; common fate; objective set; contrast; and previous experience. Information processing and storage is referred to as memory. Memory functions include sensory memory, short-term memory, and long-term memory; forgetting is the process through which information in memory becomes inaccessible. Results from several experiments show that when contents are the same in visual, audio, and print channels, learning is maximized. After the attention, perception, and processing of information, new knowledge can be applied and tested in different applications. Four figures depict these processes, including the combination of all processes in the learning helix model. (Contains 51 references.) (AEF)

The Learning Helix

Rune Pettersson

In companies around the world, teaching departments start focusing on learning rather than on teaching. In the "Age of Information" the traditional teacher will gradually disappear, and teachers will find new roles as "facilitators of learning."

Learning

Learning is a general term for a relatively lasting change in performance caused directly by experience. Learning is also the process or processes whereby such a change is brought about. In education there are a number of taxonomies for classification of learning outcomes. Learning processes may be grouped in six categories; (1) Perceptual motor-skill learning, (2) Associative learning, (3) Learning from analysis and problem solving, (4) Social learning, (5) Learning from symbols and (6) Combined learning. Categories 1-5 are not further discussed in this paper.

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 socialization, and formal 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. Only a small part of our knowledge is a direct result of formal education and formal study.

Attention, perception, processing and application are the basis for the mental model of learning that I call "the Learning Helix."

Attention

The learning process starts with attention, such as curiosity, excitement, expectation or fear. In pedagogy this is called motivation. Among the thousands of stimuli in the external context we only see, hear, smell, feel or taste 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. Most stimuli remain unknown, unseen and unheard. Attention, or mental preparedness and receptiveness, can be considered as the activation of groups of brain cells that contain previously recorded experiences, knowledge or needs. Paying attention requires mental effort, and we only have a certain capacity.

Frame of Reference

Every day, we are bombarded with information. It is hard to avoid information and just as hard to obtain the information that we really need. It is possible that we miss the information in which we are really interested.

We always have a "frame of reference." New impressions are dependent on and interpreted against the background of our previous experience and learning. Attention is never objective; it is always subjective. We direct our attention to things that move; are large, bold and clear; have bright color, an unusual shape, a good contrast as well as deviate from the surroundings or from familiar patterns. We direct our attention to contents that arouse feelings and needs. This is frequently used in advertising and propaganda in various media. Keates (1982) noted that discriminatory responses to map symbols depend on contrast in form, dimension and color. We direct our attention to what we happen to be interested in at the moment.

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.

Time Frame

Visual material and a presentation must constantly redraw the attention to hold the interest of the viewer. A presentation holds the viewer's attention when the rhythm, layout and pace are not predictable and boring. For example, when people turn on their TV sets they might not be interested in the program. In Japan TV-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 TV image and deciding if the program was interesting or not. Viewers do not take the time to actually listen to the sound. Their decisions are based on the pictorial style and contents.

Commissioned by the Director's Guild in honor of its 50th anniversary (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 favorite movies, past and present. Some moments linger for a few seconds but many are as short as eight frames, 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.

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 (Sweller et al. 1990). Clements (1984) concluded that "the attentional process is relatively diffuse" (page 146). Wickens (1980, 1984, 1991) and Klapp and Netick (1988) have suggested a multiple resource model of attention and 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, such as structural theories and capacity theories.

Attention to Pictures

Eye movements supply information on where, for how long and how often subjects actually look at different parts of a picture. Guba et al. (1964), Gould (1973), Nesbit (1981) and Dwyer (1994) all found a positive correlation between eye movements and intelligence. Highly intelligent subjects utilized more fixations than less intelligent subjects. Wolf (1970) discovered that highly intelligent subjects displayed great flexibility in their "scanning patterns," irrespective of the stimuli, whereas subjects with low intelligence tended to display a static scanning pattern that was the same for different stimuli. Nesbit (1981) found a positive correlation between learning and the number of fixations. Dwyer (1994) found that learners with higher IQ fixate more on complex instructional visuals, and that learners with lower IQ have fewer fixations as visual complexity increases. Learners with higher IQs learn more from complex visual displays than learners with lower IQs.

One of the main reasons to use pictures in a magazine, a newspaper or in a book is to draw attention to that specific material. According to Brody (1982) preference for a particular visual format does not necessarily result in increased learning. Yet, in the absence of more substantial data, information based on student preference has a meaningful role to play, in affecting learning from information materials and instructional texts. All other things being equal, we should provide formats that are *preferred by the viewer*, thus making the text more attractive and, hopefully, more motivating.

Vogel et al. (1986) showed that it is undeniable that visual presentation support is persuasive. Presentations using visual aids were 43 percent more persuasive than unaided presentations.

Even when color is not adding any important information to the visual it may still contribute to better learning because the interest for the picture increases, and learners pay attention to the picture. There are many ways to use colors to get attention to certain information. An effective, systematic, color code in a learning material assists the learner in organizing and categorizing stimuli into meaningful patterns.

Perception

Sensory organs jointly constitute a perceptual system that, in a natural environment, collects an enormous amount of superfluous information. We are often unaware of the sensory channel(s) supplying us with information. We are merely aware of the external events.

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

The Perception Process

The concept "perception" is a collective designation for the processes in which an organism obtains information on the outside world. Perception is the organizing and analyzing of the information that we pay attention to. We unconsciously make a constant effort to create some semblance of order in the impulses. We rely on our senses to provide us with data about the outside world. Points, lines, areas, symbols, colors, tones, noise, heat, cold, touch, pressure, sound, visuals and text are integrated in such a way that they can be interpreted as a meaningful whole. We rely on our experiences, thoughts and values to interpret, understand and create meaning from what we see, hear, taste, touch and smell.

In the torrent of information that bombards us, we have to select the information we want. Stern and Robinson (1994) see "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. In view of our limited capacity for handling simultaneous information, 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).

Perception. We perceive (black line) the information we have payed attention to (dot). Perception is an internal mental process that is rather fast.

The perception process is often assumed to consist of two stages or levels. Information processing is tentative, fast, rough and parallel in the first stage. It comprises all kinds of analysis, from physiological to cognitive processes. A number of different properties of a stimulus are identified simultaneously. In many instances, one analysis is sufficient. The second stage of the information analysis is conscious, demands attention as well as is detailed and sequential. Various hypotheses about a stimulus are weighed against one another, and are tested. Information processing is more definite at this level.

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 message.

Perception is subjective, and varies as a result of a number of factors, like the learner's current cultural and social status as well as the time and stage of his or her development, mood, experience, imagery and memory. This sets a "frame of reference" for the perception process. Some of our sensory impressions give rise to "garbage" and some to learning.

Individuals differ in the ways in which they perceive any given stimulus. Human perception is only sensitive to changes in stimulation. We actually perceive less than all we see and hear, and much information is never used. At the same time we perceive more than we see and hear. We believe that we see and hear things that are not there. Our brains fill 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 a reinforcement, a reward. So our perception of a text or an image depends on, for example, 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. So, a highly "saturated" information-packed message, like a picture, may have something new to offer even after having been viewed many times.

Perception "Laws"

A number of psychologists view our attempts to establish order as an innate faculty carried out in accordance with certain "laws."

Figure/ground. The contrast provided between the positive elements (figure) and the surrounding and negative space (ground or background) allows visual images to be recognized. This is the "theory of figure/ground." The context in which a visual message is presented has a major impact on the way the message is perceived. For example, the context may consist of text, speech, music, sound effects or other visuals. Our attention is on either the sound or on the image when we view a film or a TV program. This is even more obvious when we look at a multi-image slide and film presentation. As soon as the film starts, our attention is directed towards the movement in the film from the surrounding stills. It is just impossible for viewers not to be influenced by the movement.

Similarity. According to the "theory of similarity" or the "similarity law," we tend to group impressions on the basis of their similarity. Objects sharing similar characteristics such as color, shape, or size belong together. One black sheep in a flock of white sheep tends to be noticed. This can be used for emphasis of a message.

Proximity. According to the "proximity law," we group objects and events on the basis of their proximity to one another. Objects near each other belong together. The eye tends to be attracted to groups or clusters rather than to isolates. Perception is organized.

Continuity. According to the "continuity law" or "theory of direction," we perceive a slow and gradual change in a stimulus as a single stimulus. Lines moving in the same direction belong together. Events that have a natural relationship to one another also give the impression of being continuous. 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.

Closure. According to the "theory of closure" or the "natural law," various stimuli form meaningful patterns. If a figure is incomplete, our minds will fill in the missing part. For instance, letters printed with damaged or broken type are typically seen as a whole. A single dot on a paper has strong visual power to attract the eye. Two or more dots connect, and create the illusion of lines and areas. Perception is influenced by expectations. When we look at a picture, we first discover the cues we already know. Once we have identified a few well-known shapes, we sometimes feel that we have "seen everything" and could well miss valuable information.

Common fate. According to the "common fate law," objects grouped in a particular way will be expected to change in conformance to this grouping. When change does not follow this pattern, the change is difficult to process.

Objective set. According to the "objective set law" some states are perceived more strongly than others. For example, two lines that almost form a right angle are perceived as a right angle.

Contrast. According to the "contrast law," we tend to array impressions that form natural opposites, thereby reinforcing one another, in groups. Usually there is a constancy of size, shape, color and contrast in the perception of known objects. This is regardless of distance, angle and illumination.

Previous experience. New impressions are dependent on and interpreted against the background of our previous experience. Our assessments change over time and affect our way of associating. We sometimes perceive only 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.

Processing

Linsday and Norman (1977) have 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" (page 337). 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 information processing can be carried out. In psychological terms the processes that carry out this information storage are referred to as "memories."

Processing. We process information (black line) that we have attended to (dot) and perceived (grey line) into knowledge. This process is influenced by our earlier experiences and memories.

The Brain

The modern era of brain research began in the mid-1960s, when Dr. Roger Sperry and his associates published their findings regarding patients who were operated on to control life-threatening epileptic seizures (see Gazzaniga and Le Doux, 1978; Wilson, Reeves and Gazzaniga, 1982; and Sinatra, 1986, for reviews). According to 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. Most certainly there is a lot of cooperation between the two brain hemispheres. Generally speaking, dual 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. 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 (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 and 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. 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.

Processing of Text

The average person speaks about 135 words per minute (Judson, 1972) and the fastest professional TV or radio announcers speak about 150-160 words per minute. 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. We learn to sequence information, and as a consequence to think in linear, sequential ways. According to Perfetti (1977) and Sinatra (1986), perception of linear representations, such as 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).

Western societies have long placed a premium on the properties represented by a well-developed left half of the brain. The design of intelligence tests is usually such 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.

For boys, the right half of the brain is said to be more developed than the left half of the brain. With girls it is the opposite. At school children usually 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 differently than we do in Western cultures.

Processing of Visuals

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). Learning from images is different from learning from text. 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. According to 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 activities are needed. Such processes differ as a function of the symbolic systems used to convey the message. According to Gazzaniga (1967) and Sperry (1973, 1982), perception of two- or three-dimensional representations means a 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. Pirozzolo and Rayner (1979) suggested that word identification is a multi-stage process. Visual-featural analysis is carried out by the right brain hemisphere. Word naming and word meaning are processed by the left hemisphere. According to Sinatra (1986), the meaning of well-known phrase units may be accomplished without activating the auditory-motor speech system. This is said to be done by rapid interchange of information between the language center in the left hemisphere and its non-verbal representation in the right hemisphere

Norman and Rumelhart (1975, page 17) state 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) argues 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.

Using visuals to complement texts is an effective rehearsal strategy in facilitating learners achievement (Dwyer, 1978, 1985). Visual rehearsal allows the learner to process information simultaneously on several levels. The amount of rehearsal activity provided to students significantly influence the performance of students identified as external locus of control (Dwyer, 1994). Pictorial representation of information has a tendency to reduce learner dependence on verbal comprehension skills.

Sensory Memory

There are many models seeking to explain the function of our memories (see Sinatra, 1986; and Levie, 1987, for reviews). One way of viewing memory functions is based on information processing in several steps. The first of these steps is the sensory memory, which carries out the storage of stimulus information at the peripheral level. 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 temporary buffer storage, and it is fairly certain that perception relies heavily on such temporary memory stores.

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

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 iconic memory (vision) and the econic memory (hearing) are closely related to the sensory memory. These memories precede the integration of signals from various sensory systems.

Short-Term Memory

After being processed in the iconic and econic memories, some information is passed on to the short-term (or operative) memory (STM) where it is only retained for a brief period of time, that is, not more than one to two seconds. A number of complex operations are carried out here during solution of problems. But the short-term memory has severe capacity limitations. It is limited in storage capacity: most people can repeat a seven- or eight-digit telephone number, but not ten or eleven digits.

Any information to be retained in this memory must be repeated every few seconds, otherwise it will be lost. Putting new information in short-term memory pushes out the information that is already there.

Information that has entered the short-term memory can proceed through a filter (reception) that selects the information to be passed on. Once this filtration has taken place and certain information units have been assigned priority over others, these priority units are given access to a P system (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 color, size, any movement etc. Rehearsal strategies are generally used by learners to facilitate cognitive processing of new information. Without such processing there is no later storage.

Long-Term Memory

The information that passes the P system 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. 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.

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, analyze 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 the greater the possibility that increase in learning will occur (Murray and Mosberg, 1982).

The long-term memory is what most people mean when they refer to "memory." The long-term memory carries contents, episodic memories (that is, recollections of events, feelings, experiences etc.), words, pictures, concepts etc. 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 P system to the reception or to the short-term memory. The information can also get lost.

Many people, of all ages, have had accidents bringing them close to death, and subsequently described death or 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 may well remember everything that has ever happened to them, but they are normally unable to access this information.

Other Memory Models

According to the cue information theory (Adams and Chambers, 1962), information that is shared between channels facilitates learning. Cues that occur simultaneously in auditory and visual channels are likely to be better recalled than those presented in one channel only. Drew and Grimes (1985) showed that close coordination between audio and video improved audio recall of TV news, and that redundancy aided story understanding.

The dual-code memory model (Paivio, 1971, 1978) 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. Other memory models include a single-code approach. All information is coded as abstract propositions. Complex cognitive processing of information involves the use of both visual and auditory cues.

A number of techniques are available for improving memory. Buzan (1977) discussed special 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 colors of the spectrum, red, orange, yellow, green, blue, indigo and violet, uses the sentence "Richard of York gains battles in vain." The color 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 color names themselves.

According to Kossllyn (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.

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

Forgetting

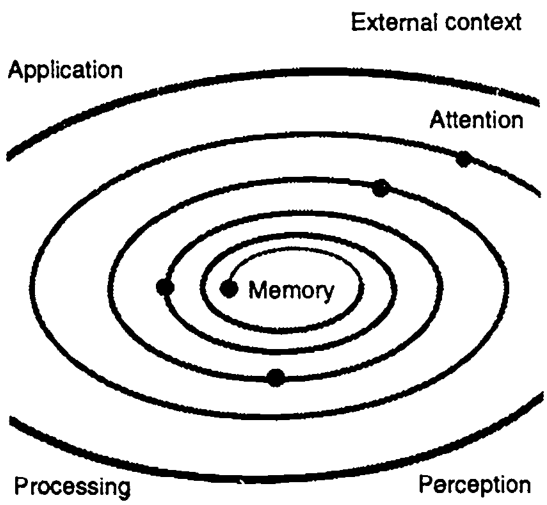
Forgetting is the process through which information in memory becomes inaccessible, either because the information is no longer stored or because it is stored but is not at that time retrievable. Forgetting is rapid at first and then gradually levels off. This process may be increased by interference 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 rather than what actually occurred.

Application

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 own property as part of our memory.

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 more easy, effective and 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 fiascoes.

Application. After attention, perception and processing of the information (grey) we apply our new knowledge and test it in different applications for confirmation (black line). Hereby, knowledge is internalized and made our own property.



The Learning Helix. 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 ...

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 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 own property as part of our memory.

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