The Mechanism of Thinking

John B. Kioustelidis, jqstel@math.ntua.gr

The mechanism of thinking is still considered by philosophers and scientists to be one of the greatest mysteries and leads some of them even to a search for yet unknown physical phenomena and mechanisms. Here we will present a different view: In order to explain this mystery we need only understand the nature of the concepts themselves. More specifically, we should take in account the evolutionary processes that lead to the formation of concepts.

The problem "How does our thought function?" has been for ever a concern of philosophers and scientists but also of common people, since thought accompanies and coordinates all our activities. During the last 50 years this question has become even more prominent, because digital computers have been developed, i.e. machines, which use logic in order to reach conclusions and give so the impression that they might be able to simulate thinking. However, in spite of the great progress achieved by science, the nature of the mechanism of thinking seems still mysterious. This leads some daring scientists even to a search for yet unknown physical phenomena. Here we will present a different view. There is no need to seek unknown physical phenomena, but it is sufficient to understand the nature of the concepts themselves and especially, to take in account the evolutionary processes that lead to their formation.

In order to appreciate what this alternative offers, we must realize at first the kind of difficulties, that are encountered during the current efforts to understand and reproduce the mechanism of thinking.

Today's difficulties

Today there are many scientific fields directly concerned with the study of how our thought functions. Some of them are: Cognitive Psychology, Developmental Psychology, Psycholinguistics, Neurology, study of Discrete State Machines, and study of Neural Networks. However, in spite of the apparent progress, there is today a wide-spread pessimism about the possibility of answering directly the question "How does our thought operate?", as we are informed by John Horgan [1]. He notes very poignantly: "Like a precocious eight-year-old tinkering with a radio, mind-scientists excel at taking the brain apart, but they have no idea how to put it back together again".

According to Gerald Fischbach, the head of Harvard's Department of Neuroscience, although neuroscientists keep finding new types of brain cells, or neurons, neurotransmitters etc., unfortunately, they have not determined how to fit all these findings into a coherent framework. Similarly, the Harvard

neuroscientist and Nobel laureate David Hubel says at the end of his book *Eye Brain and Vision*: "This surprising tendency for attributes such as form, color and movement to be handled by separate structures in the brain immediately raises the question how the information is finally assembled, say for perceiving a bouncing red ball. It obviously must be assembled somewhere, if only at the motor nerves that subserve the action of catching. Where it is assembled, and how, we have no idea."

This basic question, which is sometimes called the "binding problem", is a question that torments not only neuroscientist, but also cognitive psychologists, philosophers and generally scientists of all fields that try to comprehend the mind as a collection of relatively discrete "modules", or "computational units".

Guided by the failure of rule based methods of Artificial Intelligence, specialists in robotics are constructing today robots intended to exhibit intelligent behavior by directly interacting with their environment. However, Rodney Brooks director of MIT's Artificial Intelligence Laboratory admits that the robots they build just don't work anywhere nearly as well as biological systems and suspects that some vital component, an organizational principle, concept or language is still being overlooked [2].

The disappointment about the failure of determining a coherent model of the mechanism of thinking has brought forward another category of scientists, who are often physicists or mathematicians. These believe that the mechanism that binds together all the partial functions of the mind is due to yet unknown physical phenomena. Thus, the mathematician Roger Penrose suggests that the interconnection of the various mental functions, their combination, is due to yet unknown quantum effects, which come into play at the level of microtubules, minute tunnels of protein that serve as a kind of skeleton for cells.

However, nothing of this kind is necessary, as we shall see. The present models of organization of the Long Term Memory, i.e. of the permanently stored in the mind information, meet insurmountable difficulties in their attempt explain how the memory operates, because they overlook the evolutionary processes that lead to the formation of the conceptual system.

The main question and some known theories of organization of the Memory

The main question, that these theories find difficult to answer satisfactorily is:

How can the concepts be analyzed into elementary components?

Which are the "atoms of meaning" that compose all the concepts, like the chemical compounds of atoms compose all substances?

Such "atoms of meaning" have not yet been identified in spite of hard and persistent efforts that have been made.

Another question that these theories do not answer is:

How does the storage of knowledge in the mind begin?

They usually present a static network of logical relations, which are supposed to determine the interrelations between all concepts, but they don't explain in what order these concepts are acquired. A young child begins to communicate with other people long before he has acquired a full understanding of the fundamental concepts. How does he do so?

These difficulties are more apparent if we consider briefly two well known such theories:

(a) The *Theory of Semantic Networks* goes back to publications of Quillian and Collins from the years 1969 and 1972, but has many subsequent versions. This theory creates networks of logical concepts, which are defined by composition of their elementary logical features and organized in hierarchies of increasing generality of the concepts. Thus, we can conclude that a bird as well as a fish have skin, since both these categories are subcategories of the concept "animal", which has this typical feature. Thus, this theory and its modifications order the concepts according to their degree of logical generality and achieve in this way the "hereditary" passing of properties from the more general concept to the more specific ones.

However, this raises the question: Which concept is created earlier, the concept "bird" or the concept "wing"?

In order to define the concept "bird" we must say that it has wings. However, in order to define the concept "wing" we must also say, among others, that it is an anatomical part of a bird. It is not possible to define what is a wing just on the basis of its shape, because there are innumerable shapes of wings. Thus, the concepts "bird", "wing", "feather" must, apparently, be created all at the same time without any indication of how this could be done.

The basic problem of this and other similar theories is that they are concerned only with the determination of logical relations between various linguistic expressions, without relating the language to the outward world. This leads them necessarily to a circularity of ascribing a meaning to any word. They refer the meaning of an word to that of other words and, thus, they are trapped in a vicious cycle.

This shortcoming is avoided by Johnson – Laird's theory of "Mental Models". However, even this theory does not explain how the acquirement of concepts begins, i.e. how the elements of the "mental models" are created.

(b) The *Theory of Mental Models* [3].

This theory correlates immediately the content of linguistic expressions to the real world. In order to achieve this it assumes that any linguistic expressions we hear or read lead us to the construction of a mental model of the situation they describe. Characteristic of such a model is that it does not correspond to the full meaning-content of the sentences. It only exhibits how various concepts are interrelated in these sentences, without getting at first deeper into the subject what these concepts mean (how they are defined). In the place of the concepts it places initially some arbitrarily chosen mental symbols. Thus, for instance, the sentence "The table is on the right of the door and the chair on the right of the

table" is translated to a mental model [Door][Table][Chair], where [Door], [Table] and [Chair] are initially only symbols used for the determination of the relative position of these objects and it is irrelevant what each of these objects is. The symbols are replaced in the mental model by detailed descriptions of these concepts, only when this becomes necessary in order to understand better the whole scenery. For this purpose, the words are separated mainly into two categories of meaning, depending on the way they arise. Some words, like the word "uncle", are called *analytic*, because it is thought that they are based on necessary and sufficient conditions (uncle = brother of a parent) and, if it is necessary, they can be represented analytically by a mental model. However, some others, like the names of physical objects, refer immediately to external experiences and have a "meaning" based only on the direct recording of experiences. Thus, the meaning of the word "lemon" is determined immediately by the taste, shape, smell and other similar characteristics of lemons. This immediate recording of experiences by the senses is not determined further by Johnson-Laird. Here, however, we will focus our attention more on it.

A motivation, which lead to this theory were the results of experimental research on how people perform elementary syllogisms in order to reach conclusions. The experiments have shown that, when reaching logical conclusions based on various data, people do not use rules of logic or any other rules. What they seem to be doing is that they construct mental models, which exhibit imaginally (structurally) the various facts. Then, they examine mentally these models until the relation, which is sought, becomes obvious.

How do we know this? The psychological experiments show that the success in reaching the conclusion to a syllogistic problem is significantly less, if the problem is formulated using abstract symbols than with reference to concrete objects of our environment. Thus, it seems that man is not a "logical animal" in the sense of strict application of rules of logic. In order to reach logical conclusions he simply models the problem at hand with sufficient details so, that the relation, which is sought becomes immediately obvious. His success in reaching conclusions depends, therefore, on how familiar the mental model, he forms in this way, is to him. This result has been established experimentally by P. C. Wasson & P. N. Johnson-Laird [4], as well as by C. A. Riley & T. Trabasso [5]. There are even indications that the animals use mental models. This can be seen in an experiment with rats performed by Edward Tolman in 1930.

{ Figure [6, p. 131]: After they are acquainted with the maize, if we close the end of the shortest path (which is also the end of the next shortest path), the rats do not attempt to take this second path, but use directly t5he third and longer path. This shows that they have some model of the maize in their mind.}

Thus, it seems that people handle meanings by means of mental models, no matter whether in discourse with others or discourse with themselves, i.e. internal dialogue, inward thoughts. However, mental models can not yet explain

how the "natural" concepts are gradually formed in a child's mind, while the distinction of natural and analytic concepts seems also problematic. For instance, what is the concept "dog"? Is it analytic (animal, quadruped, carnivorous, it barks etc.)? If it is analytic, then we don't know whether we see a dog or a panther until the beast barks! If it is natural then we are faced with the complex problem of seeking necessary and sufficient determining characteristics of the concept "dog". How difficult this can be, becomes obvious if we look into a book depicting all the different races of dogs. There are dogs that are small like cats and others large like panthers. Some of them have long hair and some short hair, some have upright ears and some hanging ears etc.

Johnson-Laird refers correctly to a level of empirical recordings beneath the level of analytically determined concepts, but he does not explain in any way how these immediate empirical recordings, that represent the "natural" concepts, are organized.

Another view about the existence of "elementary" concepts

A totally different view about what the concepts are and how they are formed is presented in the book [6]. According to this view, all the difficulties encountered in determining the elementary concepts and explaining how they are acquired, show one thing: *There are no elementary concepts, which compose all other concepts.* The reason is simple. Logically structured concepts would be like the programs that are written for digital computers. Such a program can not usually operate if even a letter or a punctuation mark is missing. However, young children communicate to a great extent with their social environment far before they have fully developed their conceptual system. Furthermore, the attempt of a logical determination of the concepts leads, as we have seen, to vicious cycles of concepts logically determining (defining) each other, while the assumption that "natural" concepts are stored in memory empirically does not say anything about how this is done.

The above theories are at an impasse when trying to explain how knowledge is acquired, i.e. how the first concepts are formed, because they view the conceptual system statically and not in its temporal development. This is like trying to identify somebody's photograph, a momentary depiction, with the man himself. If we wish to grasp (comprehend) how our conceptual system functions, we must construct it developmentally or evolutionarily. This attempt is made easier by the fact that a large amount of experimental data and observations has been gathered by the, so called, Developmental Psychology.

Elements from the Developmental Psychology

According to the Developmental Psychology and especially the pioneering investigations of the Swiss psychologist Jean Piaget, the beginnings of the conceptual system are gradually formed by the accumulation of experiences that

connect the sensual inputs with movements in stereotypical sensory-motor (kinesthetic) mechanisms of reaction, which are called by Piaget "sensori-motor schemata". The baby has initially only some inborn reflexes. But, as it develops physically, these reflexes gradually develop into kinesthetic action- and reaction-mechanisms. These mechanisms are initially connected with a specific situation, but soon they are used indiscriminately for a variety of situations. Thus, the baby initially sucks at his mother's breast, but later he sucks also at various other objects feeling, thus, their harness, smoothness, temperature etc. gradually he also learns how to coordinate the visual perception with movements of the hands. However, he does not merely exercise in this way his ability to handle objects, but the perception of the objects itself, i.e. the way in which the environment is represented in his mind. Initially, he is not yet able to resolve the perception in isolated elements with clearly defined properties. This clarification happens gradually, as he assimilates ever more sensori-motor schemata for handling the environment. The child distinguishes (identifies) certain specific features when he has learned to handle them or to use them in some other way[1]. Even when he starts using words, after the age of eighteen months, he does not yet have a full understanding of the corresponding concepts. For this reason Piaget calls the mechanisms of perceiving and handling various objects, as well as the corresponding linguistic expressions, "pre-concepts". A typical feature of them is that they are used by the child indiscriminately in order to refer to very different from each other external situations. The logical structure of the concepts, their logical properties, which is the main object of study of Piaget, is gradually acquired up to the age of twelve years following specific stages of development. However, since Piaget considers the logical features of the concepts as the principal, the most essential of their constituents, he has focussed his attention on the logical handling of the concepts, and he didn't investigate further their empirical substratum.

Piaget seems to consider the pre-concepts as temporary, imperfect forms of perceiving /comprehending the reality, which are gradually replaced by more developed ones, i.e. by more correctly structured ones from a logical point of view. However, the pre-concepts are by no means insignificant, since they allow, as we shall see, associative connections of concepts, which logic is unable to make.

The basic hypothesis and indications that support it

In contrast to Piaget we will focus here our attention on the intermediate empirical stages of assimilating the various aspects of a concept and we will

[1] It is worth noticing, that somebody who was blinded at the age of three and regained his sight at the age of 46 is today, 2.5 years later, still unable to distinguish small objects, although his eye is perfectly functioning. He is unable to distinguish faces, he mistakes a dose for a peach, or a shadow for a step of the stairs [Der Spiegel, 18.11.02 pp. 190-199]. Obviously, certain sensori-motor perceptual schemata have atrophied or were never developed in his brain.

make the simple hypothesis that these intermediate stages, the pre-concepts, are never erased from the memory, but constitute the common fundament of various radically different logical concepts, connecting them in this way imperceptibly. As we shall see, this assumption is sufficient in order to explain the main features of the mechanism of thinking.

But how can we confirm that the pre-concepts exist permanently in the memory?

There are various characteristic indications that support this view:

(a) The young children initially "over-generalize" (as it is called in the literature [7, p. 506]) the meaning of all new words they learn. I. e., they use them indiscriminately in order to refer to totally different to each other objects, which happen to have some common empirical feature. Thus, the word, "mooi" may be used for the moon, as well as for shiny beads or buttons [8, p.36]. Obviously, the child does not generalize any concept using any kind of inductive logical process, but rather uses the same name for so different objects, simply because he uses partially the same perceptual mechanism for all of them (they are round and shiny).

(b) Even as adults, what we mainly register as the meaning of a word is how we can interact with the corresponding object, a complex of empirical associations and not any logical definition. This is why we find it so difficult to give logical definitions. If we are asked "What is an X?" we usually do not give a strict logical definition, but explain how we can interact with it (how we can use it, eat it etc.). I. e., we give precedence to empirically formed mechanisms of interaction. Water is for us primarily a drink that eliminates our thirst and not the chemical compound of Hydrogen and Oxygen. Usually, the answer to the question "What is a doctor?" is not "A graduate of a medical school", but rather "Somebody, who cures us, when we are ill". Our whole knowledge is organized interactively and not on the basis of a logical categorization.

(c) Another indication for the existence of the substratum of pre-concepts is the high speed, with which young children learn their native language. From the age of two up to the age of six they learn about nine new words every day (almost one new word for every hour they are awake) simply by listening to their incidental use [3, p.224]. This high learning speed is only explicable, if we admit that a large part of every concept preexists already in the mind when we learn its name, and that the concept acquires now merely the appropriate echoic designation. It is also worth noticing that the child knows already the fundamental words at the age of four years, but must reach at least the age of twelve years in order to learn to use them without errors, i.e. to learn how to construct mental models for the appropriate use of these word-concepts. This shows that the corresponding concepts are not logically structured in his mind, but rather have an imperfect and incomplete empirical form. For instance, at the age of five years he believes that whoever is taller must also be older and that two people with the same height (e. g. the father and the grandfather) must have the same age. Similarly, if we have a row of egg-cups with eggs and

remove the eggs spacing them in a wider row, the child says that there are more eggs than egg-cups, because their row is longer. On the other hand, if we space the egg-cups in a longer row, he says that there are more egg-cups.

he believes that from two rows of objects the longer one is more numerous, although he has previously established that they have the same number of objects, by placing them in correspondence to each other [9, p.35].

(d) Another indication for the existence of pre-concepts is that many words have multiple meanings with totally different to each other meanings. This indicates that it is not the word, which carries the meaning, but each time the semantic substratum, the pre-conceptual structures we have in our mind. For instance, the word "handle" may refer to very different to each other parts of a door, a bag, or a cup. The only common thing in all these different concepts is a sensori-motor mechanism of handling the corresponding objects. The "handles" are parts of different objects, which allow us to grasp or hold or move these objects. What provides in this case the different meaning to each word "handle" is the different sensori-motor schema we have each time in our mind, i.e. the different pre-conceptual structure.

The nature of the pre-concepts

In order to understand what the pre-concepts are and how they help us comprehend (understand and control) our environment without logical thinking let us consider what is a common feature of the concepts "walnut shell", "thimble", "cup", "calyx of a flower". A common pre-concept is a sensori-motor perceptual mechanism that allows us to use all these objects as vessels. When we handle one of them for the first time, looking at it and feeling it we note that it has a cavity. We, thus, gradually form a perceptual schema, which allows us to understand that all these objects are hollow. Each of these objects is subsequently distinguished from the others by further sensori-motor mechanisms, like holding by a handle in the case of a cup, or holding with the whole palm in the case of a water glass. The mechanism of interacting with hollow objects is inherent in all the above concepts, because it is a common basis for their associative formation. Thus, when we face a new situation, we use this mechanism automatically, without any kind of logical thinking. I.e., we do not think "The thimble is a hollow object and hollow objects can be used as vessels". What is more, it would be very difficult to define logically what "hollow object" means so, that this definition includes, for instance, the walnut shell. The definition of the mathematical concept "concave surface" does not include surfaces with irregularities, like those that exist in a walnut shell.

Much less can a young child, who takes the thimble of his mother and uses it as a fake water glass for his dolls, think syllogistically. Similarly, the young child does not need any logical definition of the concept "bird", which puzzled us above. It needs only gradually form in his mind (on the basis of immediate experience) a perceptual mechanism, a sensori-motor schema, which allows the

mental following of a bird that flies, without necessarily having a precise notion of its anatomy.

As a second example we can consider the concept "broom". Its logical definition might possibly be "A bunch of long flexible fibers" which should rather be supplemented with the explanation of usage: "It is used for sweeping surfaces in order to remove small freely movable objects, which are on it". However, such a definition does not tell us that there are many other objects of different kind, which can be used as "brooms". For instance, a branch of a tree including many thinner branches, eventually together with their leaves, can very well be used as a broom if we wish to sweep the ground in the garden or in the country. Similarly, in order to remove dirt from the surface of a table I used a periodical holding it by its back. How did I get the idea to use it as a broom? On what logical definition did I rely? How did I reach the idea to use the periodical almost instantly, without any conscious thinking?

Here we see clearly that the representation of the concept "broom" in our mind is rather a sensori-motor mechanism and that any object that has, even to a very low degree, the properties of this sensori-motor mechanism is used automatically as a substitute of a broom, when we do not have immediately accessible a regular one. This happens "intuitively", without using any kind of logical reasoning. We simply move from a regular broom to a substitute guided by their common pre-conceptual structures. In our pre-conceptual substratum the broom is a flexible object with a broad side. As we move it forward and downwards it bends and then returns to its original shape pushing whatever is in front of it. Therefore, any object with similar sensori-motor properties can replace a broom.

The necessity of sensori-motor mechanisms

Possibly, it seems to some people to be an exaggeration, if we make the assumption that for the formation of concepts, especially of the abstract concepts, a combination of sensation and movement in "sensori-motor schemata" is necessary. However, this necessity is clearly obvious from the very perceptive remarks of the famous mathematician Henri Poincaré about the way in which the concept of space results. As he remarks in [10, p. 58] for an absolutely immobile observer it is impossible to form the concept of space. We become aware that a body has constant form and simply has changed position relative to us only if we are able to restore the initial view of the body by changing our own position, i.e. by moving ourselves. Without the possibility of movement we would not be able to reach the conclusion that there are bodies with constant shapes around us. This observation is supported experimentally, for instance by means of the "kitten carrousel" experiment of Held and Hein [11, p. 264]. They raised pairs of very young kittens in the dark, allowing them to see only for a few hours every day, during which they were put in a sort of carrousel. One kitten of each pair could move and turn the carrousel, while the other one

was confined in a box that hindered its movements, and rotated together with the carrousel. Thus, the two kittens had the same visual experiences, but these were combined with movement only for one of them. In tests of depth perception performed after ten days the "passive" kittens exhibited a considerably inferior performance compared to the "active" ones [6, p.398].

The sensori-motor origin of the concepts is also a possible explanation for the fact that modern Physics, trying to penetrate the microcosm, is obliged to have recourse to contradictory and nevertheless complementary concepts like particle-wave. The concepts, by means of which we usually think, are due to the experience with objects of a size comparable to that of our body. They have no relation to the microcosm and, therefore, they are not compatible with it.

Why are the pre-concepts not directly perceptible?

But why are we unable to become directly aware of the preliminary stages of the concepts?

One reason why the pre-concepts are imperceptible, is that they have no name. The linguistic system, the words that symbolize vocally the various concepts, develop from the eighteenth month on, whereas the child has already a considerable control over his environment. Another, more important reason is that the pre-concepts are by their own nature hazy and unspecific and cannot be described linguistically in a precise manner. I. e. they "grasp" common preliminary stages of concepts that are logically very different to each other. Each such preliminary stage is a combination of visual, acoustical, tactile, and possibly also olfactory impressions as well as of movements of the body into one unique mechanism of action or reaction, into a unique interactive mechanism. These preliminary sensori-motor stages develop and become differentiated into ever more specific ones as they become adjusted to various external stimuli.

The origin of logic

However, thought is not merely based on sensori-motor mechanisms, like the ones we have considered. As we have seen, with respect to its linguistic and logical side, it relies also on "mental models" and the logical analysis of linguistic expressions is performed principally by composing a mental model. This kind of process is used, not only by children, but also by adults. The only difference is that young children are not yet so dexterous in the composition and handling of mental models.

But how do we reach the logical categories? What is the motive for logical categorization?

The main motive is the necessity to communicate with other people. The logical concepts are formed gradually as we start assimilating our native language. The young child adopts or invents names in order to describe his environment, but initially, he uses them indiscriminately for various objects with

some common feature, which may seem superficial to us. Thus, "dogie" may be a word he uses at first, not only in order to refer to dogs, but also in reference to any other animals [8, p.36] [9, p.19]. Only gradually he specializes this name to dogs and learns other names for the other animals. Similarly, as we have seen, "mooi" may not be only the moon, but also other round shiny objects, like shiny buttons on a dress.

Here we note that it is not sufficient to have some kind of concepts and to give them some linguistic expression. In order to be able to communicate, we must standardize our concepts to a commonly acceptable usage, and this process takes several years. Without this standardization, communication is not possible. It would be as if we are speaking a different language. This long lasting and laborious process of the standardization covers the pre-conceptual structures, which constitute the fundament of the concept. Perceptible are rather the logical features of the concept, those which we use in our everyday communication with others. These constitute the logical content of each concept, which is mainly described in the various lexicons and which philologists, philosophers and jurists are trying to determine. The concepts are, thus, like the various apparatuses we use. Each apparatus is accompanied by some handling instructions and these instructions are mainly what we know about this apparatus. On the other hand, we know nothing about the internal connectivity of the apparatus, but we are also not concerned about that. In the same way, we know the logical mechanism of the concepts, but we are ignorant of their pre-conceptual infrastructure, which is decisive for their operation.

The continuing evolution of the concepts

The views of Piaget, about a gradual development of the concepts up to the age of twelve years, possibly raise the impression that the concepts gradually reach a fixed final form. However, this impression is not correct. All the concepts keep on evolving and acquiring new associative components as long as we live.

Our understanding of a concept may change in various ways:

(a) because of social or technological changes. For instance, the creation of the, so called, "electronic money" has changed the conception of what is "money".

(b) by acquiring new experiences and by means of reflecting on a subject. For instance, if we happen to live for some time in a forest, we may acquire or form a deeper understanding of what is an "ecosystem".

(c) by means of a change of the values and feelings we associate with it. "Love" is something different for a young child, for a young adult and for an old man. Similarly, for a young child a chair is a big object, on which he can climb with some risk. For a young adult it is merely a piece of furniture, on which he can rest for a while. For an old man it may mean relaxing or suffering depending on how comfortable it is.

Some people may think that changes of valuation are superficial, so that they do not constitute a genuine change of a concept. However this is wrong. Many important discoveries of Science are only due to a change of valuation of the data. Thus, the heliocentric system appeared at first as a change of the point of reference. Its considerable advantages became obvious later. Similarly, the imaginary numbers resulted by accepting that the quantity $\sqrt{-1}$ exists. The same happened even with the negative numbers. It is significant that Descartes considered the negative solutions of equations not as genuine solutions and he called them "wrong solutions" [12, ch. 17.9]. Even the great physicist and mathematician of the 19th century William R. Hamilton objected to the acceptance of the negative numbers as well as of complex numbers [13, p. 156].

Does the fear we feel, when we see a snake, have a "meaning" or not? If it has, then the meaning of the word "snake" is not exhausted by a linguistic definition. Generally, we have to consider the question: Do the feelings have a "meaning" or are they a mere "disturbance" of thinking? If they do have a meaning, then the meaning of the concepts is varying, since the feelings have variations. Thus, the concepts are for us somewhat like the various apparatuses we use. Each apparatus is accompanied by instructions of usage and these are mainly what we know about this apparatus. On the contrary, we know nothing about the internal connections of the apparatus, but we are also not concerned about that. In the same way, we know about the concepts their logical mechanism of usage, but we are not aware of their pre-conceptual substructure, which is decisive for their functioning.

The driving power of the mind

But what moves this whole mechanism of cognition?

The driving powers of the mind are the instincts, which are also the sources of the feelings, the sentiments. These have been extensively investigated, but no generally acceptable theory has yet been created. There are various schools of psychologists, like the Behaviorists and the Ethologists (see [6], [11, ch.7 and 8], [14], [15]). The initial views of these schools were diametrically opposite, but the tend gradually to become reconciled. The Behaviorists believed initially that the behavior of an animal is exclusively due to acquired reflexes, which are formed on the basis of pleasant or unpleasant experiences. The Ethologists, like Konrad Lorenz, Nikolaus Tinbergen, Erich von Holst and others, stress, on the contrary, the vast wealth of inborn instinctive reactions, whose origins exist before any acquirement of experience. For instance, both the crying and the smile are inborn reactions appearing even in children born blind or deaf-mute, who have no possibility to acquire them by imitating other people. Similarly, still very young mammals, which never had corresponding experiences, are afraid to cross over a "visual cliff", i.e. a transparent floor extending over a true cliff, for instance, the opening between two tables [11, pp.259-261].

{Figure: The baby recoils from moving over the glass floor covering the "cliff"}

The instincts are complex control systems of the actions or reactions of an organism, which have an inborn origin. The instincts develop and become differentiated together with the development of the body, as it is clearly seen in the case of the sexual instinct. The instincts are also concurrent to each other, because, when we seek the fulfillment of one, we must necessarily neglect the others.

Some basic kinds of drives or instincts are the following: thirst, hunger, sexual drive, seeking of proximity and contact to other animals especially by young animals, curiosity, playing drive, fear and aggressiveness. The existence of the less obvious of these instincts has been established experimentally. For instance, the seeking of proximity to animals of the same kind or even to artificial imitations of them has been established, both in new born mammals and in new born birds [11, pp.214-215].

{Figure: As long as he is not hungry the orphaned baby monkey clings on the "cloth mother" and ignores the "wire mother", which offers a bottle of milk}.

Similarly, curiosity seems to be a basic instinct in higher developed animals. The opportunity to explore unknown regions is a strong incentive for the animals, in order to learn to distinguish stimuli that lead or do not lead to this result. For instance, rhesus monkeys learn to choose between yellow and blue colors just for the reward of viewing various scenes for a short while [11, p. 217].

Consequences of the evolutionary conception of the conceptual system

The position that the concepts are due to the gradual synthesis of sensori-motor mechanisms under the guidance of the instincts in stereotypical action- and reaction- schemata provides us with a possibility to explain what is that part of the mind, which is called the "Unconscious" by various psychoanalytic schools and especially by Carl Gustav Jung. It also provides an explanation of how the ability of the mind called "intuition" comes about. By this we mean the ability of the mind to jump from one concept or idea (e.g. a mental model) to some other totally different, logically strange and apparently not connected to the first one.

As we have seen, the vast network of pre-conceptual connections, that constitute the non-linguistic stages of formation of each concept, is unconscious. The pre-concepts are imperceptible, i. e. not conscious-able, because by their own nature they are hazy and imprecise, i.e. non-specific. They comprise in a sensori-motor manner some common interactive features, some common preliminary stages, of concepts, which are logically very different. For this reason we can not give them any names.

Thus, we immediately have a set of contents of the memory, which may be called "Unconscious" and it is very similar to the "Unconscious", as it is understood by Jung. I. e. it is not so much connected with traumatic experiences, but it is mainly the origin, the source, of all creative mental processes.

This part of the mind is usually expressed allegorically or symbolically, exactly because the deeper pre-conceptual levels are characterized by haziness and can not be expressed linguistically. This explains also why the messages that originate from the unconscious are in our dreams expressed symbolically, even if they do not refer to traumatic experiences.

Our dreams usually give us some message in the form of a pantomime or allegory and not directly linguistically as somebody would give an advice! Sigmund Freud says that this happens in order to conceal the traumatic content of the message, the fact that it refers to "repressed" wishes, which are not socially acceptable. However, there are also creative messages of the Unconscious. For instance, Kekule's dream, which we will describe later.

According to what we have said, the pre-concepts are anonymous and hazy, i.e. ambiguous, with increasing haziness as we move to earlier stages. Therefore, in order to explain how various mental processes are interconnected we have no need of yet unknown quantum phenomena. The interconnection of the logical concepts results through the vast and versatile network of the deeper associative sensori-motor connections, which we have called "pre-concepts". In this way it is possible to be intuitively guided from one concept to another, which is seemingly not logically connected to the first one. Such inspirations are usually expressed in our dreams symbolically and allegorically, by means of some kind of pantomime, exactly because the pre-conceptual levels have no linguistic expression. The pre-concepts are anonymous and their network is like a network of streets, which have no names. It is very difficult to tell somebody how to find his way in such a street network.

The search for relations in this chaotic system is not done linguistically, but by activating various sensori-motor schemata, which capture (comprise) some important common feature. An example of an important intuitive inspiration which was revealed symbolically in the form of a pantomime is the dream of the famous chemist of the 19th century August Kekule, which revealed to him that the benzene molecule has a ring form [16, p. 257]. He dreamt of chains of atoms, which were winding like snakes. Suddenly, one of them bit its tail and started whirling in this form. What his Unconscious was indicating to him by this dream, was that, not only the quantitative participation of each element in a molecule, but also the geometric arrangement in space of the atoms of a molecule influences the chemical properties of a substance. Perhaps we should add here that Kekule had possibly a higher developed sense for arrangements in space than other chemists of his time, because initially he started studying Architecture and only later he turned to Chemistry.

Can we construct thinking machines?

An other important conclusion, to which this conception leads, is that, if we wish to construct genuinely thinking machines, these must be robots able to interact with their environment and to assimilate new experiences, i.e. to embody them in sensori-motor schemata. Our whole knowledge and the way it is stored in memory is interactive. I.e., we learn how to interact with the environment and not some abstract logical relations. In order to be able to approach the human mental abilities, the robots must, therefore, interact with the environment, just as people do.

However, they should not only have a similar organization of their memory, but they should also have the ability of symbolical (spoken or written) denotation of the concepts, as well as the opportunity to standardize their usage by continuous communication with the human social environment. This will not be a quick process, because it requires genuine and continuous interaction with this environment. Of course, the robots could operate much faster, but the interaction with people must necessarily proceed on the basis of the reaction speed of people and not of machines.

What is more, every such robot will need at least instinct mechanisms for self-preservation, curiosity and fear, but also for social contact and social enrollment (seeking a ranking in a social hierarchy), because without social instincts there is no motivation for learning the native language and for cooperation. Possibly, it also needs instincts of aggressiveness, because the search for a solution is some sort of chase, a modification of the hunting instincts. The connection of these instincts with everyday experiences will also lead the robot to some kind of self-awareness, i.e. it will separate experiences referring to the robot from others related only to the environment. Creating machines with instincts requires, of course, the creation of mechanical models for the instincts. This seems to be possible, but it has not yet been sufficiently studied. Such is, for instance, the, so called, hydraulic model of Konrad Lorenz [14, p.34]. However, this model does not fit all kinds of instincts.

Obviously, the eventual future creation of all these technical prerequisites can not be totally denied, but it is very difficult and requires extensive study of many mechanisms of the nervous system and especially of the instincts. However, the most important fact, which we must stress here, is that such a machine will not be controllable. It will have reactions, which will be just as unpredictable as those of a human being, whose personality we don't know. It will have the ability to form free associations on the basis of the experiences it acquires, and therefore, it will intrinsically have a "free", i.e. not controllable, will.

Of course, something that is directly possible to achieve and it is already done in out time is the simulation of ever more specialized kinds of information processing and especially the cooperation of man and machine, (e. g. in remotely controlled robots).

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Figures

1. Tolman's experiment, which shows that rats are able to construct simple mental models [6, p. 97, fig. 3.12].
2. Ambiguous picture of an old woman/ young girl, which shows that our inclination determines what we see [6, p. 97, fig. 3.11].
3. Picture of a young ape clinging to a "cloth mother" [Bunk-Tausch: Grundlagen der Verhaltenslehre, Westerman Taschenbuch, Braunschweig 1975, S. 144].
4. The kitten carousel of Held and Hein [6, p. 398].
5. Picture of a "visual cliff" [Gregory, Eye and Brain, Weidenfeld and Nicolson, 3. Ed., London,1979, p.188] .

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