Memorising and Forgetting in the Human Brain

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Abstract: - The ability to save and hold data in the memory belongs to the most important characteristics of the human brain. The human brain must record and clear huge amount of information during the human life while it must never overload with records too early, as the life is long and the memory must work during the whole life. The paper shows principles of memorising information in biological tissues. The existing and new theories are depicted to show how the brain memory can work.

Key Words: - Memory, Memorising, Forgetting, Information, Human Brain, Neuron, Axon, Axon-Hillock, Dendrite, Dendritic Tree and Connections of Neurons in the Brain.

1 Introduction

This is the third paper in the series of papers called Human Brain. The previous paper Connections in the Human Brain was introduced on MCP congress held in Crete 2001 organised by WSES.

The human brain has ability to memorise information. Scientists have been searching for the concrete region in the brain where the memory can reside to discover the function of the brain memory in details.

However, such region has never been discovered so far. Some other scientists have many different theories about the function of the memory in the human brain.

This paper tries to show some possibilities of how to look for the memory in the brain and how the brain memory works or at least how it can work with regard to the neural structures of the human brain.

The human brain must work for the whole our life and it must be able to save enough amount of information during the relatively long life.

The modern life requires memorising of much bigger amount of information than ever before. How much information can the human brain contain and where are the limits of the brain memory. This is the question asked by many people.

As the human brain does not have unlimited capacity to hold information, it must forget some information to set free the neurons and other structures for other useful information. The brain is able to memorise a lot of information but not all we would need.

It is known the young people memorise information easier that the elderly people. The very old people are better able to recall that happened many years ago than that happened few years ago.

The ability to memorise information depends on many factors of the concrete person. The main goal of this paper is to show some factors that affect human brain memory so the people could to influence the quality of the memory.

In the next chapter is shown the typical distinguishing the memory types as they are known in the literature.

In the following chapter there are depicted the principles or techniques showing how the human brain can record information in its biological structures.

The knowledge of these principles can show how the brain really works with memory records.

As there is not much known about these principles, much is derived from knowledge of principles of the brain function and mathematical principles.

2 Brain Memory

The brain memory is divided to the three basic groups in literature.

1. ***Short-term memory STM*** is the first of these memory types. Information is held only for a very short time in such memory. Mostly short-term memory can hold information for seconds maybe few minutes.
2. ***Medium-term memory MTM*** is the second type of memory. Information is held longer in such memory; approximately minutes, hours or days.
3. ***Long-term memory LTM*** is the third type of the brain memory. Information in such memory is held from days to years or often the whole life.

Short-term Memory - STM

The short-term memory is believed to hold information for about minutes or for a similarly short time.

The function of the STM can be demonstrated using vision system and retina. Let us imagine that human

eye is exposed to the short-term light impulse. This impulse will generate train of impulses that go from retinal ganglion cells to the brain. Eye nerves consist of axons that transfer impulses using saltatory conduction. The every impulse goes from one node of Ranvier to the next one. It means that the every impulse is moved from one "memory" cell to another one. Now let us imagine that whole impulse train goes through the axon the same way as well as one impulse. The time delay between sending and receiving of the impulse gives dynamic memory that is used in digital computers.

However the delay time is very short to establish memory that would hold information for about 1 minute. The time necessary to transfer impulses from one end of the nervous system to the most distant one is quite very short. It is known that response time of a driver that had to stop car due to the obstacle on the road is about 300 milliseconds. The eye receives information about obstacle and the driver has to push car brake. The time that is necessary to initiate movement of the leg is 300ms. It means that time of the signal transferred using saltatory conduction is substantially shorter than 1 minute from one end of the body the second end.

The STM can be defined as a memory that is able to hold information in the "soft" form. No irreversible changes of neurons may occur in the brain. The typical STM as it is known can include reversible changes in the neurons. The period for which can the STM hold information can be shown on the example of work with a computer. I have noticed very interesting example. Many program systems installed in computers are not flexible. The user needs to make notes on paper when he or she wants to put information into the computer. The reason is that so is in the STM.

Medium-term Memory - MTM

The medium-term memory is believed to hold information for about minutes, hours or days.

The MTM memory does not hold information "soft" way. The information must be written in the brain using structural changes that allow recalling information after longer period than it was in the case of STM.

Definition of the medium term memory says that the MTM is also not able to hold information until the end of life. The information saved in MTM is also forgotten after certain time. Therefore the information is held in the neurons using reversible changes of these neurons and their connections.

This kind of memory has been described in [6] on the example of habituation and sensitisation of big marine snail called Aplysia. Both, habituation and sensitisation are also described in [5]. The habituation is the process that limits activity of neurons or ganglion cells when they are permanently excited. After certain time such cells decrease activity. When excitation is stopped cells start coming back to the original status. However the cells do not get back to the original status. Their activity remains permanently limited. This process corresponds to the long-term memory.

Long-term Memory - LTM

The long-term memory is believed to hold information for the very long time which means that information can be recalled during the rest of the whole life or at least during many years.

The mechanisms of the LTM have been partially described in the chapter describing the MTM memory. The permanent memory record can be created in the brain memory by destruction of ion channels. The increased workload of the neuron can cause its destruction or dysfunction.

The LTM memory can also be created using creation of new structures.

Problems with Defining the Human Brain Memory

The main problem of distinguishing the memory according to the time the memory memorises information is not very precious, as this theory does not define internal brain structures that record information.

The time the memory record is held in the brain depends on the method of memorising. The different methods have its technological limits that overlap for each method of memorising.

The better way is to show how the brain can memorise information and than we can define what is the STM, MTM and LTM memory.

The different technologies work at one time. Taking into account also overlapping the time intervals the concrete technology holds information we have many problems to find how the human brain memory works.

Therefore, I decided to find some of principles or technologies applied in the brain that allow us to hold information.

3 Electric Dynamic Memory

The electric dynamic memory is based on the principles of the electronic dynamic memory known I the computers.

Such memory holds information on the capacitor. The quality of the record decreases with time. Information is spoiled when the voltage of a bit decreases under the threshold level of the receiving unit.

This type of memory we can find everywhere in the human brain. The axons are communication lines

transferring information using saltatory conduction neurons. The saltatory conduction is the principle of jumping the information from one cell to the next cell.

The axon is divided into many intersections. The each one can hold information for very short time and to transfer it to the next cell. The each intersection has length of 1/e, where the e is Euler's constant equal to 2.718281828459, approximately.

The capacity of this memory is marvellous. The number of neurons in the human brain is about 10^{11}. The number of these cells creating all axons in the whole human brain is about 1000 or 10000 times bigger that the number of the neurons.

Therefore the number of these cells can be about 10^{15}. The capacity of such memory is very interesting.

The dynamic memory can hold information for very short time. However, as the human brain is feedback system where information can circulate within the whole brain, the memory records can hold a lot of information for relatively longer time than is the time of information transfer in axons.

The typical example of the using this memory is overwriting the text from one printed material to the word processor in the computer.

The person reads the text and types it in the word processing program. The typical is that the person reads one sentence or more and types it. After some words written it must read the text again as it is not able to memorise all text at one time. More experienced people can memorise more information and type it at one time.

The important is that such information is useless for the typist therefore it is not recorded in the brain. Rather the information is immediately forgotten.

4 Chemical Dynamic Memory

The chemical dynamic memory is very close to the electric dynamic memory. The impulses transferred via axons and dendrites help to move chemical substances inside the axons and dendrites. The typical chemical substances are neurotransmitters.

When these chemical substances enter the neuron they increase the threshold level for generating the impulse or impulse train in the axon-hillock.

There exists certain time between the information as the electrically charged particles entered the neuron and when they started to leave neuron from the axon-hillock.

This is one of possible principles that can be used by the human brain to memorise information.

These memory records do not cause irreversible changes if they last for a very short time. But they change the status of the human brain.

The human brain changes the charging of the most of neurons at each time. The each change creates different memory record.

The energy required to create such record is bigger that the energy is necessary to make the record in the electric dynamic memory.

Therefore the memory records in the chemical dynamic memory are more stable than for the electric memory.

The chemical dynamic memory is also responsible for STM memory but it can hold information for longer time than the electric dynamic memory.

The chemical dynamic memory is activated if the person memorises information for longer time than as in the case of typing information from paper to word processor.

For example when we watch pictures in the gallery we are watching it for longer time to hold it in the memory.

After some time we forget details. We can recognise it when we see it again, but we are not able to describe it in all details. Some information is recorded in the STM but some also up in the LTM.

The chemical dynamic memory can be responsible for STM and for MTM depending on time interval of recording the information into the brain.

5 Habituation and Sensitisation

The habituation and sensitisation was researched using the big marine snail Aplysia californica. The snail was placed in the aquarium. The gentle stimulus using a jet of seawater was applied to its body. The output of the measurement was amount of withdrawal of gill, which is another part of the snail's body.

The important was that the amount of the withdrawal was decreased with repeated stimulations. After 10^{th} stimulation the size of the withdrawal was about 25% of the first withdrawal. This process was called habituation.

If the stimulation was repeated after one-day delay the size of withdrawal was bigger than after the 10^{th} stimulation. The trial was repeated after more than one-day delay. The size of the withdrawal was bigger with the length of the delay. The withdrawal size was recovered nearly to the original size.

The cause of this principle might account for decrease of excitatory input or increase of inhibitory input. Some structural changes occur.

This type of memory can be considered as the MTM. This memory can record medium-term record. Such records also change the status of the whole brain.

The energy required to write records is bigger than for the chemical dynamic memory. Therefore, memory

records created using this type are stiffer than the memory records created using previous principles.

The habituation is the principle needed for the ordinary life. People need to habituate to many occurrences of the human life. The typical example is to wear the suit. If this principal did not work we would not be able to wear anything on our body.

The sensitisation is opposite to habituation. The loss of stimulus recalls processes that return all processes in the brain to the original status or nearly to this status.

If the stimulus is applied for long time, the structural changes in the brain become permanent. The principle of the memory is then rather LTM than MTM.

The habituation creates quite deep records and structural changes. These changes are in some cases permanent whereas at some cases are removed.

The habituation is responsible for memorising whereas the sensitisation is responsible for forgetting.

The habituation is one of principles used by students when they learn for exams. They can memorise a lot of information needed to pass the exam but shortly after the exam they forget much of memorised information.

After longer time remains only knowledge about sources where to find the information that will be required in the practical life.

The habituation when applied for long period cause permanent records in the brain memory. These permanent records can be called static records that create long-term memory (LTM).

6 Theory of Static Memorising and Forgetting in the Human Brain

The theory of static memorising and forgetting in the biological tissues includes processes static memory records responsible for long-term memory (LTM).

These processes are interesting in many regards as they cause structural changes of the human brain. The structural changes of the human brain are very important because they can influence and control our life for many years after the record was written into the brain memory.

As we know only a little about how the real human brain create permanent records, we have to have some theories about such process and during the time we have to compare new knowledge discovered in the research with these theories.

The human brain develops two different ways. The first one way that was generally accepted for many years is destruction of neural structures in the brain by the use of these structures in the life. People have believed that the brain when used looses synapses, neurons, axons and dendrites. It seems to be true that such process exists in the brain. As this process destroys neural structures it was called as destructive process. We take into account that this process can be responsible for memorising and for forgetting as well.

For many years people believed that the human brain only looses its structures and that new structures are never built again. What we get during prenatal life we have for the whole life.

New theories depicted in [5] show that probably the human brain grows and it creates new neural structures during the postnatal life.

The human brain of the newborn child is much smaller than the brain of adult person. The brain grows and it increases the size of the scull. The force of the growth is so big that the brain creates its inverse figure into the inner surface of the scull. What is the force that can do it? The human brain must grow.

In such case there is the question about permanent loss of neural structures with no creation of new structures. New structures must be created. But what the principles of the growth and built of new neurons and other structures.

The creation of new structures can be responsible for new memory records called constructive memorising and forgetting. These constructive processes can create new records and cause also that some existing memory records are never accessible again. Therefore, some information can be forgotten. When such records become unused they are removed after some time from the brain.

There exists process in the brain that shows on existence of constructive forgetting. The human brain develops during the childhood by creation of new records in the brain. During the adultness the brain creates new records while the person do its job. It is interesting that adult people do not remind much from the childhood or these people do not want to recall anything from the childhood.

However, the old people forget much from they were doing in theirs jobs and they start to remind much from the childhood.

There is a theory of growth of neural structures and its loss in the higher age.

The memory records are stiffer when they are built using repeated processes. The typical example is learning or doing the work requiring the mental work. The routine manual work has less impact on the development of the brain structures than the pure brainwork with minimum of manual work.

7 Constructive Processes in the Human Brain

The constructive processes in the human brain are as follows.

The first typical process is creation of new branch of existing axon. The each neuron has only one axon

outgoing from it. But this axon can have more branches. The new branch creates new records when it is connected either to the neuron body or to any dendrite or to another axon.

The second example is creation of new neuron. There are no verified theories about how the brain creates new neurons, as the people believed for many years that neurons are not built in the brain at all.

The third example is facilitation. The facilitation is increase of the size of neural structures. Neurons can become bigger, axons can have bigger diameter, dendrites can also have bigger diameter.

The increase of the size of neural structures increases dynamics of the human brain. The increased dynamics of the brain is structural change that can be responsible form memorising of some type of information.

For example the movement or motion of athletes is memorised using facilitation processes.

It is known that repeated learning is better than the forced fast learning. The reason is in facilitation of neural structures during slow learning. The fast learning cause rather destructions.

8 Destructive Processes in the Human Brain

The destructive processes in the human brain are as follows.

The first typical example is the loss of axon that did not accessed its target for a long time.

The second example is loss of neuron that does not receive energy supply from previous neuron for a very long time.

The third example is destruction of synapse and/or dendrite.

The fourth example is deprivation. The deprivation is opposite process to the facilitation. The neural structures while not used decrease its size. This is called deprivation. The deprivation has the biggest negative effect for young persons. When the children are not taught some information during theirs childhood, they can never learn it later during the life. The typical example is language. The first language must be taught during first years of life. If not, the child can never learn it any more.

The children that grew up with animals can never learn language.

9 Learning Processes in the Human Brain

The learning processes in the human brain include both, constructive and destructive processes. When we learn something we facilitate our brain for this purpose or this information. For other purposes the brain is deprived. It means that when we learn mathematical or technical sciences we lose abilities for arts. The most of people can learn both but not in the highest possible level.

There exist a lot of human activities that are opposite to other activities. The mathematical sciences and art was only an example of two antagonistic human activities requiring different activation of the human brain.

10 Associative Memorising

The learning creates associative memory records. It means that each type of human activity has its own inner relations that must be learned or taught by the human brain.

The constructive and destructive processes create associative memorising. During creation of associations something is memorised and something is forgotten.

The explanation of the associative processes in the brain can effectively start with description of neuron types according to Golgi.

The Golgi divided neurons into two basic groups – Golgi type I, and Golgi type II neurons.

The Golgi type I neuron (G1) has the bigger body and it has dendrites and one axon. This neuron can lead electric current only one direction. It means, from dendrites to the neuron body and to the axon.

The Golgi type II neurons (G2) can contrary to G1 lead electric current all directions. It has small body and often it has no axon or axon is short and often the axon is not connected to any other neuron [1, 5, 6].

The function of the Golgi type II neuron is very different from the Golgi type I neuron in the main point. The G1 neuron is living neuron whereas the G2 neuron is dead neuron. The G2 neuron was probably created from the G1 neuron. The probable cause was interruption of axon or any other type of destruction of the axon or neuron body. Such neuron probably changes to the tissue similar to ligament.

The ligament is the tissue that arises in the place of infarction on the human heart after the infarction is completely cured. The main characteristic of the ligament is similar to the characteristic of the G2 neuron.

The ligament can lead electric current faster than the ordinary living heart tissue. It is stiffer but it does not have function of contraction.

I have based the theory of the G2 neuron as the dead G1 neuron just on this principle. It is very probable that it is really so.

Now let us reason about what the brain does with G2 neurons to use them for some useful functionality. These G2 neurons connect and join other neurons.

Short cuts occur in the places where they were not before. These short cuts can be used as associative memory.

11 Programming the Human Brain Memory

The human brain memory changes during the whole life. The changes are built during the ordinary life everyday. Depending on how we live we build records in the brain memory. Positive thinking creates more constructive records whereas the negative thinking creates more destructive records.

Strong depressions and anxieties cause decrease of blood flow speed in veins. The decrease of the blood flow speed in the veins probably decreases the flow speed of the brain fluids. Although depressions and anxieties increase number of impulses in the brain, the gradients necessary to move brain fluids decrease.

Therefore, strong negative feelings can cause the very slow but permanent loss of all neural structures.

The positive feelings on the other hand open veins for the blood. The flow speed of the blood in the vein increases. The same way it increases the gradients that control the flow of the brain fluids.

The negative behaviour of some people to other people comes from some kind of depression or anxiety. People commit criminal actions, etc. All these actions can also be considered as anxieties. The relaxed people behave well to others. Therefore, the negatively oriented people lose more brain tissue than the positively oriented people.

The loss of neural structures increases instability of the human brain. The instability of the brain increases fear, depressions and anxiety. All these feelings slowly destroy the human brain. The person in anxiety gets to the circle from which it cannot escape easily.

The substantial loss of neural structures cause weakening of the brain inner power. The decreased brainpower can result disadvantage for the affected person.

The mentally weakened person feels its disadvantage against other people. Therefore it starts to defend against everything that is not dangerous in real.

Such defence is understood by other as attack. Therefore, these people start also to defend against the original person. Therefore, aggressiveness increases in case of loss of brainpower.

Therefore, everybody should control quality of his/her memory records.

The quality of memory records affects the life after these records have been recorded to our memory.

12 Conclusions

The paper has shown that memory records are of many different types. The temporary memory records build the permanent memory records if they reside in the memory for a long enough time.

The permanent memory records control our life very substantially. The most of permanent memory records reside in the brain memory for the rest of our life.

These records are in some cases not accessible during the life. But in the end of the life they are recalled. Than people can see all their actions in “another light”. In the end of life the very big amount of neurons change from G1 to G2. It means that the substantial number of neurons become associative neurons of the G2 type. Therefore, the people can see the previous life in the context they could never see it before. The young brain is not able of such associations.

The associations built during the life and the end of the life show to everybody the real meaning of all was memorised in the brain before.

The brain memory is responsible for the high level feedback that controls people in the community or in the society. The actions and corresponding reactions from the outer World are controlled by the brain memory as well.

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