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Brain Function on the Basis of Biological Equilibrium – The "Triggering Brain"

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Abstract

A model of brain function is presented that is consistently based on the biological principle of equilibrium. The neuronal modules of the cerebral cortex are proposed as units in which equilibrium between incoming signals and the synaptic structure is determined or established. Because of the electromagnetic activity of the brain, the electromagnetic properties of the cells are brought into focus. Due to the synaptic changes of the modules - essentially during sleep - an electromagnetic resting balance between the modules is established. Incoming signals during the day, disturb the electromagnetic resting equilibrium and are detected and understood by this. The connecting nodes within the neuronal network are given by the equilibrium modules. Incoming information is represented in the form of the specific pathway of the network, while recognized information is represented by the equilibrium states within the modules. The paper leads to an understanding of information storage and processing in the brain. It even provides a hypothesis for understanding the emergence of the "self". Finally, the consideration of electromagnetic wave properties of neurons opens up a biophysical starting point to understanding conscious perceptions. In neuroscience, we lack a unifying theory of the brain. The reason for this may be an important detail – a missing link – that we do not yet see. Following the "track of biological equilibrium" in this paper leads to the hypothesis that the electromagnetic properties of the neurons are potential candidates to fill that gap. A hypothesis is developed describing their physiological significance in the processing of neurological information.

Key Words: Biological equilibrium, electromagnetism, brain function, neuronal representation, actual information, potential information, self, consciousness

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Introduction

The principle of biological equilibrium is ubiquitous. Every biological function and thus every biological structure serves this principle in some way. In this paper, the brain is described by consistently tracing its functions back to the biological principle of equilibrium. The assumption is that understanding the processes of equilibrium will lead to a better understanding of how the brain works.

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Thus, a change of perspective is made for the description of the brain. Using the Krebs cycle as an example, we will illustrate how this is to be understood: The Krebs cycle is a cyclic, enzymatic production chain for the generation of NADH. It is a central function in the energy supply of the cell. This knowledge is very important for the understanding of a cell. But related to the organism it is a strong simplification. If we study the Krebs cycle in terms of the equilibrium processes of the whole organism, it becomes clear that there must be a function that ensures that NADH is produced only in cells where energy is actually needed. Otherwise, the balance of the organism in terms of respiration and blood supply, etc. could be disturbed. Cells that are currently at rest should produce less or no NADH. If we follow the "track of biological equilibrium", it reveals that the Krebs cycle is actually not a simple production chain, but rather an ensemble of equilibrium relationships. It produces NADH only when it is consumed. It follows, as all enzymatic reactions, the law of mass action which describes an equilibrium relationship.

The opportunity that comes with the proposed change in perspective is that new insights can be gained. Interrelationships that we do not yet see or understand could become clearer. A famous example for this: Only as a result of space travel, we learned that there is a biological equilibrium relationship between bone function and gravity. It turns out to be necessary for the physiological triggering of bone growth. For the scientific community, this discovery was a great surprise.

The brain is the result of an evolutionary process. The first, primitive neuronal structures control, within physiological limits, the balance for the whole organism. This relates to stimuli, such as the concentration of nutrients in the environment, the direction of incoming light, the flow of water, and the like. Subsequently, the orientation of the organism or its metabolic activity with respect to the exogenous stimuli is adjusted to achieve physiologically favorable conditions. In principle, there are two possible states: "Balanced" or "Unbalanced". "Balanced" represents the physiologically most favorable situation and "Unbalanced" a deviation from this. Technically understood, this is a "triggering" of biological reactions in relation to exogenous factors. In mathematical terms, this would be a relationship according to the pattern "a/b". Where "a" represents stimuli at hand and "b" represents the biological response. However, mathematics is often not available for biological structures, which is why mathematical ratio equations are rarely used in biology.

Konrad Lorenz (1976) introduced the concept of "mirroring" in the biological sciences. Lorenz recognized that biological systems always mirror their environment. The wing of the bird reflects the air. The fish fin is a reflection of water. It is in each case properties of the biological structure that match properties of the associated medium in the same way as a mirror image matches the original. Depending on the biological task, nature can take the most different ways. Thus, also the lung in Lorenz's sense is a mirror of the air and the gill a mirror of the water, just of completely different characteristics of these two media. In biological mirroring, the equilibrium relationship reveals itself only at the level of function. For example, of buoyancy in wing/air, of gas exchange in lung/air, or of chemical reaction in enzyme/substrate. At the level of function, reflections, in Lorenz's sense, represent biological equilibrium relationships.

Balancing equilibrium is a biological principle. In what follows, we present a model of brain functioning that is consistently based on this biological principle. Given the complexity of the brain, this model will initially be sketchy. The term "Triggering brain" will be used for the hypothesis in the following.

First Step: Equilibrium Structures in the "Triggering Brain"

Incoming signals have to be evaluated in the brain whether they are known or unknown and whether they disturb the biological balance or not. The brain must determine whether incoming signals are "Balanced" or "Unbalanced". In the model of the "Triggering brain" neuronal structures are proposed, which are able to check whether incoming signals are in equilibrium with information already stored.

The most likely structures for this are the neural modules of the cerebral cortex described by János Szentágothai (1976). Hebbian learning takes place essentially between these modules. They have different synaptic setups, in which the neurological representation of information is assumed by many researchers. These modules are found in all brains studied to date and also in neural tissue outside the brain. They appear to be phylogenetically ancient. Their number in humans is billions. The cerebral cortex consists of almost nothing else. But they are also an essential structural element in the deeper parts of the brain. In anatomy they are summarized by the term "gray matter". The modules are very small. They consist of only a few, about 10, rarely as many as 30 nerve cells. Under the microscope, they are easily distinguished from each other histologically. They are close together, like the individual knots of a carpet. Together they form a layer of modules. Just as skin cells form a skin, for example. In the upper layer of this module layer, there are billions of thin neuronal fibers that crisscross like a felt in all directions. Axons enter and leave the modules at the bottom. They connect modules with each other, creating a neural network. Many of the neural pathways make connections to the diencephalon. In understanding the "Triggering brain" hypothesis, we are looking at a neural network of equilibrium modules.

The measurement of whether an exogenous incoming signal is in equilibrium with an already existing synaptic pattern takes place locally, and only within the equilibrium modules to which the ascending neural pathway leads. In the equilibrium module, a new signal is generated that is transmitted to other parts of the brain if there has been a prior learning process (Hebbian learning) that has caused the formation of the neural pathways required for this purpose. "Balanced" results represent recognized information. The slow differentiation of equilibrium modules and connections among them through learning, gives rise to modules for similar inputs close together. "Balanced" results for similar phenomena, such as language, or objects can thus be generated and interconnected more quickly and with relatively little energy expenditure. The generation of balanced results very locally, favors the emergence of specialized centers in the brain without having to be genetically determined.

The equilibrium modules can be found in all parts of the brain and also in the spinal cord. They are responsible at their respective location for triggering equilibrium between an input signal specific to the particular neural tissue and the pre-existing synaptic setup. They assume the "Balanced" state when equilibrium is present. Note that the "Balanced/Unbalanced" describes only a possible state in the "Triggering brain" model. It is not a neuronal signal itself. Which signal in the "Triggering brain" is considered for transmission is still unclear.

Brain responses are either qualitative or quantitative. Qualitative responses can be reduced to a sequence of yes/no results. These, like binary values, can be understood by the described distinction of "Balanced" and "Unbalanced". Quantitative results, however, correspond to analogous values. They are needed, for example, to produce a spatial balance of signals from the two ears, or they are necessary for stereo vision. The functionality of the equilibrium modules should therefore be able to generate the state "Balanced" or "Unbalanced (Minus/Plus)" in the result. The "Balanced" state represents an existing equilibrium between an input signal ("a") and an existing synaptic setup ("b"). The two "Unbalanced" states signal that there is no equilibrium. In this case the input signal deviates from the existing synaptic setup in one of two possible directions.

Mathematically, an equilibrium module could be understood as a quotient ("a/b") describing the ratio of the input "a" to the synaptic setup "b". The neuronal network of equilibrium modules would then be a cascade-like network of quotients. Many outputs of the brain would be like continued fraction operations, because in the course of signal processing an "a/b" output of one module can become the "a" input of the following module. This explains why we prefer to perceive natural phenomena which, on closer inspection, reveal themselves as continued fraction phenomena. This is for example the harmony of tones and colors, or the proportionality of the golden ratio. Perceptions of this kind lead in the "Triggering brain" to faster and clearer "Balanced" states, because the modules interconnect with each other as continued fractions structures.

In the model of the "Triggering brain" the neural network is to be understood as a cascaded network of equilibrium operations. The connections in the network are not binary switching points but modules that assume equilibrium states. These remain as long as the input is present. This is true even if a signal has long since been forwarded.

It is to be mentioned that these are biological processes that always have a certain spread. For example, signals from neurons that travel axially always lead to radial neurological changes in the immediate vicinity. The equilibrium process in the neuronal module therefore rarely takes place only within a singular module, but more often through a group of spatially close neighboring modules. They are similar to each other, but not identical. As a result, there is some biological variance. It is to be expected that input signals which occur very frequently lead to clearer (sharper) equilibrium results than others.

The proposed equilibrium operations will be illustrated with an example: When looking at a face, the incoming signals from the optic nerves run into the visual center. There they are fed into a multitude of already existing neuronal equilibrium modules. Within the equilibrium modules, a comparison of the incoming signals takes place in relation to the pre-existing, somehow encoded knowledge (the synaptic setup). Equilibrium modules in which a synaptic setup exists that are in equilibrium with the incoming signal pattern assume the "Balanced" state. In all other equilibrium modules, the incoming signals do not cause "Balanced". In the "Triggering brain", after the signals from the optic nerves are combined to form a neuroequivalent image, a single equilibrium result of "Balanced" at the higher level of the cerebrum would be sufficient to distinguish, for example, the quality "Face" from other qualities such as "Building". From a pool of equilibrium modules in which known faces are stored, a secondary "Balanced" state for "Aunt Anny" is created for a test person, for example. The subject recognizes the face of "Aunt Anny". Suppose Aunt Anny has a twin sister "Carol" and the two look so similar that they are often confused with each other. And let's further assume that the subject knows this. In this case, there could be an equilibrium module for "Aunt Anny or Carol" in which a "Balanced" condition would then arise. If the "face" then says "Hello!", a triggering of the now acoustic signals proceeds, starting from the ear. But because Anny has a clearly different way of speaking than Carol (which the test person also knows), after processing the word "Hello" only the equilibrium module "Aunt Anny" generates a "Balanced". The subject can respond "Hello Aunt Anny." In this case, there would be three equilibrium modules for the face of the two twin aunts: "Aunt Anny", "Aunt Carol", and "Aunt Anny or Carol". Only one of these three modules will produce a "Balanced" state based on the visual and auditory signals present.

In the first step, neuronal equilibrium modules were proposed and their basic integration into the neuronal network was discussed. In the following, the question will be addressed of how the "Triggering brain" makes it possible to link equilibrium results that originate from completely different sources and for which there is no recognizable common learning experience. For example: Why do we have no problem seeing flying cars in a movie? Or: Why can an artist paint a horse blue and it is still a horse for the viewer? The brain is able to combine different signals. It seems as if there is an almost unlimited flexibility. If this is so, then the question arises for the "Triggering brain" why the differently generated equilibrium results are compatible with each other at all, so that useful "balanced" states arise in the neuronal network.

Second Step: Physiological Range of the "Triggering Brain"

We use the equilibrium modules to go about our day. The ability to act precisely or to judge things accurately decreases during the day and we become tired. We need to sleep to restore the brain's efficiency. During the day we receive new sensory impressions. In the brain there is a continuous process of changing the synaptic setup, mainly among the equilibrium modules that are actively occupying us at the moment. Step by step, those equilibrium modules, specific for our daily needs, will change. The neuronal activity itself induces these changes through Hebbian learning. We must therefore assume that individual "Balanced" states are actually not a very sharp parameter, but rather a certain range that changes during the course of the day. In the "Triggering brain", the ability to produce a useful equilibrium result is the critical variable. If this ability decreases, then at some point a good result fails to materialize. We need to rest.

During sleep, synaptic remodeling also takes place in the brain. Some researchers suspect a kind of calibration process is occurring. During the REM phases, preferably those modules are activated that have undergone the most synaptic changes. These are also exactly the modules that were used during the day. Towards the end of each REM phase and especially in between, synaptic growth is observed. It is assumed that this process is necessary to make the brain fit again for the following day. In the model of the "Triggering brain", it is assumed that the synaptic adaptations during sleep change those equilibrium modules that were active during the day in such a way that they can again provide an accurate equilibrium result in the next waking phase. The affected equilibrium modules are then even available with higher precision than before, because what was newly learned is now integrated into future equilibrium determinations. During the fatigue phase, the synaptic changes of the day had increasingly disrupted the equilibrium operation. Now, after the adjustments of sleep, they become a fully integrated part of future operations.

The brain doesn't just need to sleep; it must also awaken. The two states of wakefulness and sleep separate the processing of information (during wakefulness) and the storage of information (during sleep). If the daytime activity would lead immediately also to storage, then a large amount of information would be stored, which is not at all relevant for further life. Due to the absence of sensory perceptions during sleep, they are left out during calibration. During sleep, a calibration of the equilibrium modules takes place. However, not with regard to the newly acquired connections during the day. That would make no biological sense. What has been learned must be retained.

For the model of the “Triggering brain” the process of calibration should be compared with a lawn: In the time between two cuts with a lawn mower, the plants grow. Some grow significantly faster and higher than the average. After the cut with the lawn mower, all plants have the same height again. However, the information about which of the plants had previously grown higher than the average is not lost because those plants have developed a larger root system, which is preserved.

The plants of the lawn represent the equilibrium modules. The cutting with the lawn mower stands for the calibration process. The growth of the plants stands for their activity during the day. The root system for the synaptic changes of the day. The result of the calibration stands for the state of the equilibrium modules at the beginning of a new waking phase.

What is calibrated? And what is the "standard"?

The standard for one meter is stored in the form of a piece of metal in Paris. The standard for one second is defined as a multiple of a certain quartz oscillation. The standard for cutting a lawn is the height setting of the lawn mower.

The sought-after, biological standard for the calibration of neuronal equilibrium modules in the "Triggering brain" must be a similarly well-defined, readily available and reproducible quantity. And it must be so every night the brain sleeps. Independent of the environment in which the brain lives. From birth to death. And (within physiological limits) also independent of the current physical constitution of the organism.

Chemical substances are rather unlikely candidates for the standard we are looking for, because after decades of research on the chemistry in the brain, we would certainly know that. Therefore, there is probably only one quantity left to which this requirement applies: the electrical noise. The brain is an electrochemically working organ and therefore always produces an electromagnetic noise with one or more, characteristic electromagnetic waves. All neurons, after all, have a basic metabolism, even in the resting state. They are living cells. A variety of chemical activities in the cells, along the membranes, between the cells, at the synapses, etc., collectively contribute to the basic electrical noise. Because most of the cells are biochemically very similar to each other and during sleep they are all in the same state - at rest - this noise is very homogeneous. We measure the brain's electromagnetic noise as EEG. Many research results suggest that the synaptic setup of the brain during sleep occurs in such a way that it is gradually changed so that the resting noise is no longer disturbed. During the REM phases, insufficiently calibrated cells are recognized by their not-yet-normalized electromagnetic activity. They are further modified until their signal matches the resting signal sufficiently well. This explains why the length of REM phases decreases during sleep until they eventually cease altogether and the brain awakens again. REM activity, in the model of the "Triggering brain" is a measure of the equilibrium modules that are not sufficiently calibrated with respect to the resting noise.

Let us go back to the biological principle of balancing equilibrium: this is exactly what happens through calibration during sleep. In the "Triggering brain" all modules are balanced relative to all others so that they are in a resting equilibrium with each other and can maintain this equilibrium until they are excited by incoming stimuli. What is normalized here is the resting state. During calibration, the "Triggering brain" uses the signal from all equilibrium modules to create an electromagnetic resting equilibrium among the modules on this basis. The calibration creates a zero level.

Future excitation of the equilibrium modules produce results that are electromagnetically different from the zero level. They can therefore be processed. Since the modules now operate uniformly on a "zero" basis and are all balanced by synaptic adjustments during sleep, the two sides "a" for inputs and "b" for stored synaptic setup should also be balanced against each other. The "Balanced" represents the equivalence of these two sides. The state "Balanced" therefore corresponds to an equilibrium value of "1".

The physiological range of the equilibrium modules with respect to their electromagnetic properties lies in a range that is limited downward by the electromagnetic resting level. Upwards, the range is limited by the state in which the input signal and the synaptic setup of the module are in equilibrium with each other.

Equilibrium is always the preferred mode of existence in biology. Not least because of the lowest energy demand in this state. Equilibrium is a state of undisturbedness, of homeostasis. Equilibrium modules that are not currently active are not at rest solely because they are not firing, but especially because they are electromagnetically balanced against all other, non-firing modules. For the understanding of diseases of the brain and the mode of action of some drugs and intoxicants this is an important clue. How does the neural network system change when the calibration ability of individual modules, or individual regions, or the brain as a whole changes?

The "Triggering brain" model provides us with a basis for understanding the mathematical performance of the brain. There exists a "0" for each equilibrium module and there exists a "1". Both are defined the same everywhere in the cortex. A single module thus provides everything to map a complete number line. Because of its integration and position in the neuronal network, it also has a unique specificity and can therefore represent a whole dimension. Thus, the module can be used for yes/no tasks as well as for comparative tasks. Three modules are sufficient to define a point in space. Because all of the modules within the physiological range are adjusted against each other, the equilibrium result of one module can be used for arbitrary operations in any other module. For this reason, anything can be interconnected with anything in the brain. Cars can fly in a movie and a horse can be painted blue and still be recognized as a horse.

More recently, some researchers are investigating the extent to which the electromagnetic behavior of cells plays a role in the correct formation of organs. Why do skin cells close a wound by growing and dividing, and stop doing so as soon as healing is complete? It is assumed that the cells must be in electromagnetic balance with each other. The hypothesis: An injury of the skin causes a disturbance of this balance and triggers the healing process. This comes to an end as soon as the wound is healed and the cells have restored their electromagnetic balance.

If we understand the carpet of equilibrium modules of the brain as a skin that forms the organ by folding, then in biological analogy, a signal that disturbs the resting equilibrium could have the same effect as an injury to the skin. The processes of Hebbian learning and of calibration would then be comparable to that of healing.

We know very little about biological processes concerning the electromagnetic behavior of cells. It is a very young field of research. What we always find is the fact that evolution uses all available environmental factors to achieve biological equilibrium. Could the biological significance of electromagnetism surprise us in a similar way as gravity did in its time?

Third Step: Information in the “Triggering Brain”

In the model of the "Triggering brain" it is proposed that as a result of the equilibrium operation of the equilibrium modules, we obtain a "Balanced" state whenever the excitation signal "a" is somehow in equilibrium with the stored synaptic pattern "b". But what is actually meant by the state of equilibrium of "a" and "b"? How does a "b" look like compared to an "a"? We need to understand these two.

In neuroscience, the activity of neurons is observed in the form of the formation of action potentials (spikes). They are generated and transmitted in active cells and can in turn trigger spikes in subsequent cells. The presence of spikes means neuronal activity, their absence means neuronal quiescence. For many years, attempts have been made to find in the properties of spikes a key to understanding neurological information. Is neurological information somehow represented in the spikes? However, it is repeatedly shown that the variability of spike events is very high and no sufficient reproducibility can be observed. Additional spikes occur spontaneously again and again or disproportionately long pauses occur, so that clear explanation patterns have yet be found. Could it be that in the firing of the cells of the brain the sought-after information is not represented at all?

In the nerve-muscle connection the spike triggers a contraction, and in the nerve-gland connection a secretion. In the nerve-nerve connection, a spike triggers secondary spike. We transfer this finding to the nerve-nerve connection in the brain and therefore investigate spikes. Is it conceivable that spikes in the connection between equilibrium modules invoke completely different mechanisms? Like how a glandular or muscle responds to a spike with completely different functions. Muscle or gland cell cannot respond with spikes because they are not nerves. But does that mean, conversely, that a subsequent nerve cell can only ever respond to a spike with a spike? Are not completely different reaction possibilities and functions conceivable?

The model of the "Triggering brain" suggests this, because it focuses on the electromagnetic behavior of the cells due to the electromagnetic calibration. The electromagnetic properties of cells are apparently fundamental to the biological balance of the brain and to its function. If spikes only trigger the processing of information, then the fact of their occurrence might be more important than their pattern. How is information represented in the model of the "Triggering brain" if not by the spikes?

Understanding calibration in the "Triggering brain" model brings the electromagnetic properties of cells into focus. The brain calibrates itself during sleep and establishes a resting equilibrium in the form of a balanced electromagnetic state. Excitation of cells by incoming signals (spikes) disturbs the resting state. Excited cells experience changes in their electromagnetic behavior and generate an altered electromagnetic field. The characteristics of this field are determined by the electrochemical makeup of the individual cell: by its location in the interconnection of the neurological network and its neighboring cells, by its synaptic equipment, by its size, and by the excitation signal itself. The "a" is thus a unique, representative quantity for the excitation state of a module, in the form of an electromagnetic wave.

When "a" is present, the rest equilibrium of the module is also disturbed. Based on the biological equilibrium principle, we now expect a biological solution within the module to restore electromagnetic equilibrium. It is therefore obvious that the "b" is also represented by an electromagnetic wave.

In the equilibrium module the two waves of "a" and "b" must be brought together. When two waves are brought together, physically a superposition of the two waves takes place. An interference signal is generated. Compared to all possible states of wave superposition, the one of mirroring (!) is of a special kind. The mirroring of waves leads to the complete, so-called "destructive interference", where the two wave signals cancel each other out. The destructive interference is different from all other superposition states. It is unique and therefore suitable to define the state of "a/b" as "Balanced". The coding of "b" is then the synaptic setup of those cells of the module in which the "b-wave" originates. It is the encoding of an electromagnetic state which, after superposition with "a", leads to interference. The wave resulting in the activated state of a module would then be the superposition wave of "a" and "b". The more accurate the mirroring of "a" by "b", the more destructive the interference and the less interference signal is preserved. In the case of complete, destructive interference, a complete "Balanced" is present.

In order for a once encoded "b" to repeatedly lead to the generation of destructive interference with a future "a", there must be a mechanism of phase alignment of the two waves. This is given in the simultaneous excitation pulse by the spike. Note that the expression "a/b" does not describe a wave division! This is physically not possible. "a/b" describes on a pseudo-mathematical level the biological equilibrium.

The requirement of the synaptic modification of "b" has already been described in this paper. It is the calibration of the modules during sleep. The adaptation of "b" now can be understood as a triggering of the wave superposition towards the point of complete destructive interference. As soon as this condition is established (this point is reached), the incoming signal and the setup of the module are in equilibrium with each other, so that a "Balanced" state exists.

It is important to emphasize that the point of complete destructive interference is defined by the laws of wave physics. It is not a biological quantity! There are no genes, no physiological processes, or any biological factors involved for having it available. It existed forever. Long before the evolution of live started. And it is independent of the differing characteristics of electromagnetic waves as we find them in the brain and generally in biological systems. Thus, this "value" (this condition) is the most reproducible quantity we can think of - for triggering any kind of electromagnetic equilibrium phenomena.

In the modules a ratio "a/b" is generated, where "a" stands for the input signal and "b" for the already existing synaptic setup. Here, "b" corresponds to a setup that encodes a signal that, when superimposed on "a", leads to the generation of interference. The pattern "b" in turn arises due to learning whenever the signal "a" is present. As long as "a" is not present, there is no matching "b" and the modules cannot assume a "Balanced" state. For this reason, a largely empty brain, such as that of newborns, will be in a perpetual state of arousal. It must develop considerably stronger neuronal activity in the waking phases than a mature brain in order to successively differentiate a sufficient number of modules that are capable of generating a "Balanced" state. Only in this way can the biologically desired resting equilibrium be achieved.

A summary sketch of the equilibrium modules of the "Triggering brain" now describes the following entities:

- Structures that receive input signals. In the excited state, they generate an electromagnetic wave that deviates from the resting state. Through Hebbian learning, they undergo synaptic changes. Connections with other modules are formed.

This is the representation of the *incoming information.* It corresponds to the "a" of the model.

- Structures that, based on calibration during sleep, are synaptically adapted to produce an electromagnetic wave in the arousal state that creates interference with "a". Synaptic adaptation is complete when a sufficiently high level of destructive interference is achieved.

This is the representation of the *stored information.* It corresponds to the "b" of the model.

- Structures in which, in the excited state, the electromagnetic signal from "a" and "b" are combined so that wave superposition occurs.

This is the representation of the *recognized information.* It corresponds to the "a/b" of the model.

- All structures exhibit a uniform, electromagnetic rest wave in the rest state.
- The structures are synchronously excited by spikes.

The above entities enable the following functions:

- A module represents partial information by its location in the neuronal net.
- The module checks the degree of correspondence of this partial information with the already stored information (coherence

check).

- Depending on the check result, the module reacts in different ways.
- In the case of complete, destructive interference, the coherence check in this module ends.
- Coherence deviations lead to the adaptation of the stored information and to the formation of links to other modules.
- Both the adjusted information within the module, and the new links among modules, enter future coherence checks.
- In a cascade of modules, a cascade of coherence checks results.
- Synaptic adjustments allow electromagnetic equilibrium at rest.
- All modules operate in the same excitation range. This is limited on the one hand by the homogeneous electromagnetic resting noise ("0") and on the other hand by the state of completely destructive interference ("1").

The specificity in terms of stored information is understood as the electromagnetic deviation of the equilibrium module from the rest state. This means that in the module's excited state and after calibration, the same unit of information is represented in each of the two electromagnetic states "a" and "b". And this is in the form of a mirror image. Within a cascade, from stage to stage, the mirroring flips back and forth. "a1" becomes "a1/b1", equals "a2", becomes "a2/b2", equals "a3", becomes "a3/b3", and so on until the end of the cascade is reached. This results in equilibrium relationships in both directions of the cascades. Upward with increasing specificity and downward with decreasing specificity. The excitation of a cascade triggers an equilibrium process in all associated modules, so that representations can be adjusted simultaneously at all levels. The continued fraction relationships among modules contributes to efficiency. Modules that are further down in the sequence have less influence on the outcome at the end of the cascade. The neural network thus provides a pool of information at different levels of specificity that can potentially be recognized and used to maintain biological balance.

The storage of information occurs, on the one hand, through the differentiation of the synaptic setup of "b" within a module and, on the other hand, through linkages between modules through Hebbian learning. The two processes are complementary with each other. Learning complex things takes longer and requires more frequent day-night cycles than simple things. For information storage, this means that the calibration to complete destructive interference not necessarily happens in one step. The less destructive interference can be achieved in a module during sleep, the more (stronger) neuronal linkages with other modules are created through Hebbian learning. In this case, the module resides at a deeper level of its cascade. However, when complete destructive interference is achieved, the module becomes to be the end of its cascade. The two processes of “a-learning” (= Hebbian learning) and of “b-learning” are in an equilibrium relationship with each other. “a-learning” is the process of creating network connections while “b-learning” is the process of restoring the electromagnetic equilibrium of the network-nodes - the modules.

The term "information" has been used in the "Triggering brain" model so far without defining it. In the neuroscience literature the term usually refers to an intuitive understanding of “information”. This understanding of "information" can be described approximately as follows: "information" is an entity that is somehow encoded and represented and can be read/received and understood/processed. This also corresponds to the definition used by authors like Shannon and many others. In the age of computers and bits, when the goal was to study artificial systems for processing information that can actually be received, read, understood, and processed, this was an appropriate starting point. In understanding how the brain works, however, the intuitive understanding of "information" has not led to any breakthroughs.

Carl Friedrich von Weizsäcker (1985) describes the nature of "information" in a different way. "Information" is either in the form of "Actual Information", or in the form of "Potential Information". "Actual Information" can be received, read, understood, and processed. This partial definition corresponds to our intuitive understanding. "Potential Information", on the other hand, is information that can only be potentially understood. The availability of an additional process is required to transform potential information into actual information. An example shall clarify this: Visualize now the Sydney Opera House! The neural structure in which the appearance of the Sydney Opera is represented is probably present in most readers. It is "Potential Information." It is not received, read, understood, or processed until it is transformed into "Actual Information" by some process. Reading the words "Sydney Opera" triggers this process. Only now does the idea stored in the brain of the appearance of the Sydney Opera come to the surface of consciousness. Now it is "Actual Information" for the brain.

Von Weizsächer's definition of "information" involves a probability function. The existence of a process to transform potential information into actual information follows a given probability. If we express this in a formula, then for the emergence of actual information (a_W) from potential information (b_W) we get the following relation: $a_W = p(W) \times b_W$. And further: $a_W / b_W = p(W)$. Here p(W) stands for the probability (p) of a processing process (W). The subscripts of a_W and b_W indicates the v.Weizsäcker definition. With this definition of "information" we have an access to the understanding how the evolution with the help of the biological equilibrium principle could make the use of information possible. This understanding allows a separate view towards the process (W) of converting potential information to actual information and of the management of probabilities (p) to initiate that process.

In the model of the "Triggering brain", the two representations of "a" and "b" are complementary pieces of information. When they are merged into "a/b" (the wave superposition process), information is created that can further be processed. The process of merging "a" and "b" corresponds to the "W" of v.Weizsäcker's definition. The probability ("p") is given by the probability of the occurrence of the "a" input signal.

The model of the "Triggering brain" contains a hypothesis how the neurological representation of information can be understood on the basis of equilibrium modules in the neural network. This describes a biological system that is able to receive, store and recognize information. The system offers an evolutionary advantage as soon as the organism is able to make use of this pool of information.

Fourth Step: The "Self" in the "Triggering Brain"

In the model of the "Triggering brain", the cortex of the cerebrum is to be viewed as an ocean of equilibrium modules that are essentially stimulated by the sensory organs and that check to what extent the signals are in equilibrium with what has been learned. At the same time, the cerebrum feeds itself with what it has learned. It uses the same modules and mechanisms for this as for the signals of the sense organs. In the billionfold network connections of the cerebrum it is not distinguished whether a signal "a" comes from the external sense organs or the body or whether it is based on an "a/b" signal, which was created by a previously learned "b". An "a/b" arrives in a following module like all other "a". The cerebrum feeds itself with signals from the learned just as if they too came from a sensory organ.

In the cerebrum, signals of sensory origin and those from acquired, synaptic patterns flow equally into the "stage" of consciousness. However, not from the beginning. After birth, the individual must first use his sensory organs to gradually adapt all the equilibrium modules necessary for reproducible sensory perceptions. In the earliest phase of infancy, equilibrium modules are adapted that make it possible, for example, to see sharply, or to distinguish directions, colors, sounds, etc. Gradually, the cerebrum learns that optical perceptions have to do with the eyes, acoustic with the ears. The brain learns to differentiate the senses and to use them selectively. An understanding of each of the senses is formed. For seeing, hearing, smelling, tasting, touching. The cerebrum learns to distinguish whether a detail of the consciousness is based on signals coming from the sense organs/body or not. At the same time, it processes sensory perceptions and knowledge in the same way. For this reason "knowledge", in the model of the "Triggering brain", is to be understood like a sense organ. It is differentiated step by step by the incoming stimuli of all other sense organs/body.

Sensory perceptions of different kinds produce characteristic qualia, which we experience in our consciousness in the form of feelings. The feeling characteristic for "knowledge" could be what we call the "self" and experience with the "I-feeling". It arises as slowly as knowledge arises. Successively the "self" becomes enriched with knowledge about its own corporeality, so that there are more and more comprehensive body feelings that go along with the "I". The "I" becomes a content of consciousness, much in the same way as every object, sound, taste, smell or touch we perceive, is a content.

With the acquisition of knowledge about the sensory organs and the development of the "I", important basics are acquired in the brain, which the organism needs to be able to live in its environment. The cascaded organization of the equilibrium modules leads to an understanding of the environment as a hierarchically structured world. Categories are formed and entities are ordered. Concepts are developed that allow, for example, to distinguish a "before" from an "after". Or an "in front of" and a "behind". An understanding of time and space develops, so that the dynamics of perceptions are understood. The brain develops an understanding of quantities and learns to count. It differentiates "causes" and "effects" developing the foundation for our cause-effect thinking. The cascading organization of equilibrium modules leads hierarchical relationships and logic to become an intuitive fact.

Fifth Step: Consciousness in the "Triggering Brain"

In the model of the "Triggering brain" the physical basis for the transmission, storage and recognition of information is based on electromagnetic properties of the nerve cells of the equilibrium modules. Spikes excite the cells and let to the generation of interference waves. When interference is complete and destructive, a state exists that signifies fully recognized information. In this state, both the wave representing a specific information and the rest wave (because the excitation signal is canceled out due to destructive interference) are present within the same module. This corresponds to the physical condition for the formation of holograms: the electromagnetic image of an entity and the reference wave coincide in one point. Holographic sensations are another very special condition in wave physics. They could serve as an interesting new starting point for our quest for consciousness.

The hypothesis provides a hint to understand how conscious perception of recognized information becomes possible in the cerebrum. However, this would explain only a part of consciousness. With the assumption of electromagnetic effects (such as holography) in the cerebrum, the perceptions merely fill the "stage" of consciousness with "props". A scenery has been created. But it is still relatively poor in content with respect to the meaning of the "props", because they are all on an equal footing. The most important task of the consciousness is the use of that information to trigger biological equilibrium. Consciousness becomes biologically meaningful only when the perceptions are endowed with relevance to the overall balance of the organism.

When we are conscious we are able to direct our sense organs. With the eye we have the highest degrees of freedom for this. We can focus points in the whole space and concentrate on single objects of our "stage". It is as if we had a "pointer" with which we can focus to the point of interest. It is the same with hearing, tasting, smelling, touching, but with fewer degrees of freedom. With the help of the "pointer" we concentrate ourselves towards a specific perception. It seems as if we can freely decide where to point the pointer. In the visually perceived environment we can concentrate on single points in space. The musician can concentrate on the melody, the rhythm, or the harmonies of a song. The sommelier focuses on bitter substances in the wine, the perfumer on the lavender note in a perfume, the sculptor on the shape of an object, etc. For each of the senses there is the possibility to focus on individual details from the pool of perceptions. If we understand the "self" quite analogous as a sense, then the functionalities of the "pointer" should apply as well, and with the highest degree of freedom: The scientist focuses on an observation of the experiment.

The control of the senses is located in the structures below the cerebrum. In the functions of the diencephalon, together with functions for storing/recalling procedures with the cerebellum, everything is present to control and use the senses, from bottom to top and from top to bottom. The concept of the "pointer" in the "Triggering brain" is to be understood as a summary of the control functions of the diencephalon that are perceivable to us. Focusing on a sense perception is a function of the "pointer" that we can perceive. Simultaneously with the focusing of a perception, we experience the enrichment of this perception with feelings. The two functions of the "pointer" (focusing and feeling) make all other perceptions fade into the background. None of these perceptions has completely disappeared - they remain within "reach", so to speak - but they are less important for the brain. The focused perception thus acquires a significance for the "I", that goes beyond the mere perception of the “props”.

It can be assumed that feeling is not only generated "online", but that it is also stored in the equilibrium modules of the cerebrum. We link feelings such as "beautiful", "scratchy", "smelly", "loved", etc. to our memories. Feelings are thus linked to stored information of the senses, including the "self". Feelings generated online by the “pointer” therefore should be recognized in the same way as sensory perceptions through "Balanced" states and become conscious through the same effects.

The cerebrum's main task is to recognize states from the environment and the body. They all have to be learned. To this end, it must provide very flexible linking capabilities. This is a requirement that stands in the way of efficient probability management in terms of using this information and maintaining biological equilibrium. This problem is solved by the function of the "pointer". The "pointer" allows the brain to focus on certain contents of consciousness. At the same time, other parts of the perceptions do not remain completely unnoticed. They are within reach. In associative proximity.

In the sense of v.Weizsäcker's definition, the information provided by the cerebrum is potential information for the "Self". It can be converted to actual information for the "Self" by the pointer. Thus, on the level of consciousness, the function of the pointer is to be understood as a further process "W". The question that follows has to deal with the probability "p" for the pointer on where to focus. This question is basically the same as the question about the "Free will": Do we have it or not? From the perspective of the model of the "Triggering brain" this is a question of understanding the probability management of the pointer. From the perspective of the equilibrium management for the whole organism, the development of the cerebrum and of consciousness only makes sense if those functions allow to differentiate perceptions and to choose among them, within physiological limits, the most favorable options for reaching equilibrium.

With the concept of the "pointer" a functional separation between "perception/knowledge" and "control/thinking" results in the model of the "Triggering brain". There is the level of recognition of current information located in the cerebrum. This is the more factual level of current circumstances. For example, a factual element is a tree in the visual field, including the knowledge that this is a tree. For the biological process of equilibrium, which has to involve the whole organism, this level is not sufficient. The second level, controlled by the diencephalon, focuses on specific content and adds relevance in the form of feelings. Only through this the wholeness of consciousness as "my stage" is assembled. In it the "self" is present and it is able to report: "I see a tree".

Discussion

The model of the "Triggering brain" proposes three major hypotheses.

No. 1 – Equilibrium Modules

The cerebral cortex consists of billions of modules where each one is able to generate equilibrium between an incoming signal and the synaptic setup of the module. Modules are interconnected in a cascaded network due to Hebbian learning. Their synaptic setup is modified due to a calibration process, so that it serves two tasks: All modules work on the same rest level and within the same range. In the state of excitation the synaptic setup allows to recognize information.

No. 2 – Electromagnetism

The electromagnetic properties of the cells of the equilibrium modules are fundamental for generating equilibrium. Electromagnetic states are essential for saving and recognizing information and for consciousness.

It is proposed to consider the ubiquitous condition of complete destructive interference for biological equilibrium processes.

No. 3 – The “Self”

The "self" arises step by step from the accumulation of knowledge about one's senses and body. It is managed by the brain in essentially the same way as any other sense.

The "Triggering brain" model summarizes well-known facts from biology and neuroscience. Not a single one of these facts is controversial in the scientific community. This should be considered a strength of the hypothesis. On the other hand, the way the facts are linked with each other is new and unusual. Therefore, in the otherness of the linkages between old known phenomena, its biggest weakness must be assumed as well. The model requires several changes of perspective.

The starting point is the ubiquitous, biological principle of equilibrium. While hardly any scientist will disagree with this principle, in terms of how the function of a nerve cell in the brain is generally understood, it requires a new perspective. According to this, the nerve cell is not only a component in the process of transmitting signals, but also a component in maintaining the electromagnetic equilibrium of the brain. Evidence for this can be seen in the electromagnetic behavior during sleep and in the synaptic changes that accompany it. With embedding in the skull and even head hair, evolution has developed very elaborate protective functions for the brain. Obviously, they serve less to protect against damage than is commonly assumed. Severe injuries to the cerebrum often do not preclude its ability to function. The protective functions could be parts of an electromagnetic isolation of the brain, which serves to stabilize the quality of electromagnetic fields.

The histological appearance of the neural modules of the cerebral cortex described by Szentágothai suggests that the three structures proposed, are distributed among differently differentiated cells. Inferences from the evolution of nervous systems may lead to the same assumption: With the elongation of organisms, longer and stronger nerve cells became necessary. Structures to isolate the nerve and to refresh spikes evolved (e.g. Myelin sheaths and nodes of Ranvier). These structures must lead to relatively heterogeneous electromagnetic interference with biochemical processes in the surrounding cells. Nerve cells that generate destructive interference and therefore attenuate electromagnetic fields represent an evolutionary advantage. They should be found mainly along the axon of the main nerve. This would have given rise to cells that are capable of producing a mirror image ("b") of the electromagnetic field of the main nerve ("a").

Life is not imaginable without electrochemical processes. In single-celled organisms such as bacteria, chemical reactions in the inner medium of the cell can often take place in a freely floating manner. On electrical charges in such cells, the medium acts like an ohmic resistance. The more developed a cell is, the more compartmentalization is present. An ordering of the electrical charge transitions takes place, so that the entire cell develops increasingly inductive properties. With the ion pumps along membranes, structures are present that allow charges to build up and dissipate. These structures behave like electrical capacitors. The coupling of capacitors and inductors in the same electrical system creates electromagnetic oscillations. In electronics, these are so-called "oscillating circuits" which are used to generate electromagnetic signals.

Such electromagnetic conditions are also present in nerve cells, and especially in synapses. We know a lot about the molecular processes concerning the excitation at the synapses – the activation, as well as the inhibition. However, we know very little about the significance of the electromagnetic effects associated with the synaptic equipment. As far as I can tell, we have hardly focused on this in neurological research.

The commonly and intuitively used term "information" is questioned in this paper. It is reminded of v.Weizsäcker's definition according to which information is either an actual or a potential object. This opens a broader perspective on the nature of information in the brain. According to this definition, information is stored by two complementary partial representations of potential information. The process of combining these two leads to the emergence of the actual information. A closer look reveals that the biological solution for storing and retrieving information follows the principle of biological equilibrium. This closes the chain of reasoning in this paper, which began with the proposal of equilibrium modules in the cortex.

The present essay is to be understood as a sketch of how, from the empirical point of view of biology and philosophy of nature, a comprehensive brain theory, to be understood in purely materialistic terms, could be developed. For this reason, and because the author does not feel called to it, the thousand fold realizations of the neurological research were left out as far as possible. This is also true for wave physics and some other scientific disciplines. With few exceptions, the usual citations in scientific works have been omitted for the same reason.

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