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The Labyrinth as a Tool in the Study of the Neuron Activity of the Brain

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Abstract

Despite a substantial amount of research, there are still many secrets about the human brain that have been left uncovered. Many scholars have focused on the brain as a network of interacting pulsed neural oscillators in an attempt to understand how it functions. The wave like patterns of the neural oscillation is highly active when the brain is challenged. The use of the labyrinth in the various experiments and studies creates a challenge for the test subject, forcing the latter to develop these oscillatory-wave patterns. In order to better read this data, and focus not only on direct observation of test subjects, scholars have introduced the neurocomputer interface (NCI), allowing to acknowledge their presence and derive conclusions. Yet, again the scholars have gone further to utilize the challenging factor of the labirynth finally testing the brain activity of humans in a state of deep slow-wave sleep. This allowed to see that the brain activity patterns noted during wakefulness spontaneously reactivate in sleep. However, only in the event of a reward during wakefulness. The labyrinth challenged the human brain, and provided a reward as a potential outcome – further to be tested and recorded. The labyrinth has proven itself to be an important tool in testing the limits of the assessed brain operation, helping scholars to push the limits of the unknown in the discovery of the true potential of the human brain.

Keywords: human brain; neurocomputer interface (NCI); oscillatory-wave patterns; slow-wave sleep; wakefulness.

Introduction

Labyrinths have been a part of human culture for thousands of years, and they continue to fascinate people today. Labyrinth studies have focused on various aspects, including their history, symbolism, design, and therapeutic uses. Scholars have conducted extensive research on the history of labyrinths, tracing their origins back to ancient times. The most famous example is the Cretan labyrinth, which according to Greek mythology, was built by the architect Daedalus to imprison the Minotaur. Other historical labyrinths include those found in medieval cathedrals, such as the one in Chartres, France.

Labyrinth design is a growing field of study, with researchers exploring the mathematical principles behind their construction, as well as the use of color and texture in their design. Some researchers have also experimented with creating new types of labyrinths, such as 3D or virtual labyrinths.

Also, Labyrinths have been used for therapeutic purposes for centuries, and recent studies have begun to explore their potential benefits. For example, research has shown that walking a labyrinth can reduce stress, improve cognitive function, and promote emotional well-being. Labyrinth studies have a rich and varied history, and the field continues to evolve as new research is conducted. Whether exploring their historical origins, symbolic meanings, or therapeutic benefits, labyrinths offer a fascinating and complex subject for study.

In recent years, there has been a growing interest in studying the mechanisms of the brain and developing models of neuromorphic dynamic systems that perform specific functions. This interest is due to the development of computing technologies and the improvement of experimental techniques. Research has shown that brain structures have remarkable abilities for processing information of various modalities and solving non-trivial cognitive tasks. Despite this, the maximum frequency of physiological rhythms typically does not exceed 200 Hz, which results in meager brain energy consumption. Furthermore, the inherent mechanisms of adaptation and plasticity make it possible to learn and perform diverse tasks in the background, such as coordination of movements, walking, and speech.

These factors indicate the superiority of nonlinear dynamic systems implemented in the brain in the form of neural networks over traditional digital calculations. This emphasizes the need for fundamental interdisciplinary research at the intersection of biology and physics, which requires the use of methods and approaches of radio physics in terms of signal generation, propagation, and conversion.

One example of such a system is a network of interacting pulsed neural oscillators – brain cells, the total activity of which is a nonlinear combination of electrical signals of individual elements. It is believed that such network activity formed in the brain forms deterministic oscillatory-wave patterns that determine the architecture of the system under study and its functional properties. Until lately, there was no possibility to test and acquire valid data on these signal patterns and naturally decipher them to make a proper conclusion.

However, recent research on labyrinth studies has provided an opportunity to better understand these patterns. Labyrinth studies provide a challenge to the mind, forcing the brain to form and develop oscillatory-wave patterns. This has allowed researchers to take the next step in acknowledging the true power of the human brain. The introduction of advanced technologies and experimental techniques has enabled scholars to test and acquire valid data on these signal patterns, leading to a deeper understanding of the mechanisms of coding, transmission, and information processing in living systems.

Moreover, labyrinth studies have potential implications for developing new therapies and interventions. Previous research has shown that labyrinth walking can have a positive impact on well-being, reducing stress and improving cognitive function. With the advancement of technology and the ability to measure and analyze the oscillatory-wave patterns formed during labyrinth walking, there is potential for the development of new therapies and interventions for various neurological and mental health disorders.

Labyrinth studies have provided a unique opportunity to better understand the mechanisms of the brain and its dynamic systems. The integration of advanced technologies and experimental techniques has opened new doors for interdisciplinary research at the intersection of biology and physics. The potential implications for developing new therapies and interventions make this an exciting field for future research.

Background

The research subject in this work is the activity signals of biological systems. The brain, which consists of many interacting cells, is a vivid example of a source of multichannel signals, where the multidimensional spatiotemporal pattern has informational and functional significance. From the point of view of nonlinear dynamics, a neuron is an impulse oscillator capable of generating an electrical discharge in response to an impact above a certain threshold. Neurons interact through synaptic contacts, which provide unidirectional signal transmission. The functioning of one element of the neural network is a sequence of electrical impulses. The cumulative spontaneous activity of the neural network can be represented as a spatiotemporal pattern of successive burst discharges, characterized by almost synchronous activation of most cells in the network at a high frequency. However, the principles of generating and propagating electrical signals in neuronal structures are unclear. To reproduce these signals, the scientists tried to experiment to get an analysis of the brain's neural activity. Naturally, from an ethical point of view, it was impossible to conduct experiments with people from the beginning. That is why in the first stage, rats became experimental subjects.

Morris Water Maze

The first attempts to collect data were carried out through experiments. The latest tests known from academic publications were accomplished by [1]. The scholars have attempted to detect cognitive impairment from mild hippocampal damage in rats, just like other scholars before and after them [2,3,4]. All these scholars agree that in order to pass the maze, a memory development through hippocampal integrity was an important requirement for the ultimate success of the test subject progression. The meaning of the behavioral task was to ensure that the rat in the water reached the rescue area, hidden from view, overcoming several obstacles with a complex trajectory [2,3,1,4]. Apart from the fact that all these scholars used the same methodology, their approach was somewhat different. Here, one presents the most detailed as explained by [1]. The swimming pool was a metal tank (100x80x80 cm), half filled with warm (21–23 ° C) water (it was whitened with milk during the training process) and divided into three compartments by partitions with three holes in each. They were covered with doors, but only one of them opened freely. The animal, placed in the starting compartment, had to dive, find the "correct" door immersed in water, get into the intermediate compartment, and, only having overcome it through the desired hole, find itself in the finishing part of the labyrinth, where the rescue platform was located at a shallow depth [1]. With this approach, the contribution of visual information during the reproduction of spatial skill was minimized, although not completely excluded.

Animal training consisted of several stages and was carried out during the week, with three training sessions daily. They were in clear water in the first two days, and the open "correct" doors were located above their level. The rats learned quickly and easily, coping with finding a rescue site [1]. On the 3rd day, the water level was raised above the doorways, and the doors themselves were covered, which led to a noticeable increase in errors. On the 6th day, the "false" doors were fixed, and on the 7th day, the water was whitened. The number of errors (attempts to open the imitation door, passing by the "correct" door, moving along the wrong trajectory) and the total time spent in the maze were considered during the learning process [1]. Rats were trained if they performed no more than three erroneous actions in three consecutive tests within one minute. As evidenced by the obtained data, the used modification of the water maze presented a more complex behavioral task for rats than the traditional Morris method, making it possible to more adequately judge the animals' memory and their ability for spatial learning [2,3,4].

(Artem P Gureev et al., 2022) showed a deficit of working and reference memory in 15-month-old-mice in the water Morris maze, and a decrease in the exploratory behavior in the open field test. In 15-month-old mice, cognitive deficits were associated with decreased Bdnf expression in the hippocampus, increased nuclear factor erythroid 2-related factor 2 (Nfe2l2) expression, and more mtDNA damage in the cerebral cortex. In order to preserve mitochondrial quality control, neural plasticity, and stop the onset of age-related cognitive deterioration, these signaling pathways may be potential targets for pharmaceutical intervention.

Mice in Labyrinth

How do animals or robots learn complicated actions from a single or limited set of experiences? Language acquisition in young toddlers, where new words are picked up after just a few uses, or learning to balance a bicycle, where people advance from utter ineptitude to near perfection after crashing once or a few times, are canonical examples. It is obvious that such quick learning of new connections or motor abilities might provide significant survival benefits.

(Matthew Rosenberg et al., 2021) conducted research on laboratory mice's behavior in a complicated labyrinth of tunnels. For one night, a single mouse is left in a cage at home with unrestricted access to the maze. The maze's floor and sides are made of a black plastic that is transparent to infrared light. Using infrared lighting, a video camera set up below the maze continually recorded the animal's movements. Offline analysis of the recordings was used to follow the mouse's motions, with emphasis placed on the mouse's four paws, midsection, and snout. During the subjective night of the animal, all observations were taken in the dark.

A binary tree with six layers of branches, running from the single entry to 64 endpoints, represents the maze's logical structure. A maximally symmetric design with 63 T-junctions connects nodes with straight corridors such that every node at a certain level of the tree has the same local geometry. A water port can be found at one of the maze's 64 endpoints. The port releases a little drop of water after being activated by a quick nose poke, followed by a 90 second time-out period.

Some of the mice lack access to water, but one spot deep inside the maze provides it. After just a few rewarding encounters, it was discovered that these animals were able to make their way to the water port. In many instances, one may spot special "aha" moments when an animal exhibits abrupt behavioral changes. All of this happened within approximately one hour. An effective form of exploration guided by straightforward navigational principles underlies the quick learning. The same patterns of exploration are seen by mice that have access to water. This laboratory-based navigational behavior could serve as an appropriate research platform for the brain processes underlying few-shot learning.

NCI Application

However, the application of the experimental design mentioned above, does not allow one to fully acquire all the necessary data on the brain's neural activity. Scientists can only test the ability of the subjects to learn and learn in terms of passing the maze [5]. This way of using the maze does not provide the necessary data on the brain's neural activity.

The scholars note that at the moment, one of the main tasks in studying the brain as a complex structure is the improvement of methods and relevant tools for collecting and analyzing the data obtained [6]. More specifically, it is crucial to decipher the information hidden in the collected data of the spatiotemporal activity of neural systems. In other words, when scholars see that something has happened (spike on the graph), they need to get information that corresponds to a certain event.

The most challenging thing today, according to scholars, is to conduct such observations, collect and analyze data in real time. This is done utilizing the NCI (neurocomputer interface), which has multi-electrode sensors. A cyclic experiment (repeating the same conditions with each attempt) is the most common format for studying the brain through BCI [7]. Studying certain cognitive functions, such as attention, memory, and learning, is possible.

Spatial navigation is the best-known and most effective method for studying the aforementioned cognitive functions. The labyrinth makes it possible. However, in this case, scientists used NCI on their test subjects [6]. During such experiments, the so--called neural space encoding (or "space code") was found in many regions of the rat brain: the hippocampus, entorhinal cortex, primary visual cortex (V1), retrosplenial cortex, and parietal cortex. These "codes" are specific signals that store information about where the rat is coming from, where the rat is in the maze and where it is going. This information must be read in real-time, and not only after the experiments, when the rat is in a state of rest or sleep (non-REM sleep) [5].

The proposed technique consists of two main stages: encoding and decoding. At the encoding stage, the overall probability density of the spike sign vector (neural signal - the action potential of neurons during extracellular registration of their electrical activity) and spatial position are created [5]. The decoding stage is responsible for reconstructing the data in a spatial position, which should correspond as closely as possible to that obtained in the previous stage.

From a hardware point of view, scholars point out that the problem of real-time data analysis can be solved by using multi-threaded software on a multi-core central processing unit (CPU) [6]. The disadvantage of such a system is the number of cores, which limits the scalability of the entire system of the brain-computer interface. The researchers decided to embed a graphics processing unit (GPU) into a conventional quad-core computer. A GPU dramatically speeds up the decoding process and expands the system's scalability [6]. The sensors themselves were also changed from tetrodes to high-density silicon sensors.

All system variants were tested during the tests: CPU-based, CPU+GPU, using tetrodes and silicon sensors. The database consisted of spikes of the hippocampus, neocortex, and thalamus recorded during spatial navigation in two-dimensional space.

As expected, the GPU system performed significantly better than the CPU system. So, in the case of test No. 1, the GPU system showed a data compression (spike encoding) threshold of 0.5 at a decoding speed of 0.02 ms/spike [7]. Under the same conditions, the CPU system showed a decoding speed of 0.44 ms/spike (1V). It is also worth noting that "enhancing" data compression leads to an increase in decoding speed and a decrease in the accuracy of this process [7]. The core bandwidth also plays a vital role in the decoding process. If this parameter was small, then the compression ratio had little effect on the decoding accuracy. In addition to excellent data decoding speed, scientists also boast a high degree of decoding accuracy.

Next, the scholars conducted an experiment in which the rat had to move through a maze as a figure-eight, and tetrodes read the CA1 region of the hippocampus and the primary visual cortex V1 [7]. The progress took place in a mixed format: separately CA1, separately V1, and CA1 + V1. Analysis of the V1 data showed that the spikes in this region contain an impressive amount of information regarding spatial movement. By combining the V1 data with the CA1 data, the scientists improved the overall decoding accuracy [7].

Core parameters were optimized for each brain area (CA1 and V1) separately based on cross-validation data. At the same time, the decoding accuracy was high. And with zero data compression, as expected, the decoding speed was meager.

The following experiment was carried out in a labyrinth, which is difficult to call, given its appearance - a simple ring. The rat ran in circles while the tetrodes read data from the anterior nucleus of the thalamus [7]. This brain area is most important in memory formation and spatial orientation.

The critical point is that most of the neurons of the anterior nucleus of the thalamus are head-direction neurons [7]. Therefore, in the data analysis process, not only the activity of the brain lobes corresponding to the body's position was taken into account, but also the position of the head because these two parameters may differ.

An analysis of the activity of neurons in the anterior nucleus of the thalamus confirmed its relation not only to the position of the head but also to the spatial orientation of the subject during the tests [7]. However, in the case of the circling test, there was a decrease in the decoding accuracy of the head position data, which was not related to the speed of the rat's movement. It has to do with the direction of travel [7]. More precisely, with the fact that both options were taken into account in the calculations - clockwise and counterclockwise.

This test (running in a circle) is essential not by the trajectory of movement and not by the complexity of the labyrinth (it does not exist, in fact, just a ring). An important factor here is the speed of the rat [7]. During running, neuronal activity accelerates, thereby correlating the rat's movement. The GPU-based system decoded hippocampal neuron spikes significantly faster (with fewer training attempts) than a conventional CPU-only system.

The tetrodes used in the experiments made it possible to obtain sufficiently accurate data, but this is not the desired limit. Therefore, it was decided to test the silicon multichannel electrodes as well. Two such sensors were placed in the left and right hippocampus [7].

It was also necessary to check how scalable the system was. To do this, the silicon electrode data was "cloned" until the number of hypothetical channels reached 2000. Next, the system had to decode this data during movement (running) and rest (non-REM sleep).

GPU optimization and the use of direct memory access enabled the following indicators: decoding time during the movement period - 250 ms, decoding time during the rest period - 20 ms [7]. In the second case, data compression was not carried out at the coding stage, and about 1200 channels were involved.

As a result, it has become known that the time required for decoding with a fixed number of channels increases significantly if the system uses only the CPU (Paninski & Cunningham, 2018)[8]. The slowdown of the decoding process when using the GPU is not as significant and does not occur so abruptly. An essential feature of this study is the reading and processing of neuronal activity data in real time [7]. A GPU system is ideal for this, as it can decode a large amount of data quickly, as previous tests have shown.

Comparing the standard post-test data analysis technique with the real-time technique, the scientists found an increase in the accuracy of the reconstruction (during non-REM sleep) of the rat's movement trajectory [8]. That is, the system reconstructed the trajectory along which the rat moved during the test more accurately. At the same time, the system analyzed the activity of neurons after the test, during the rest period (non-REM sleep phase).

This study first confirmed that reading the activity of neurons in real-time is possible. When it comes to such a complex system as the nervous one, any delay in analyzing its activity dramatically reduces the accuracy of the data obtained [6]. That is why this study is so important.

With the help of their technique, the scholars were able not only to build the route of the rat's movement, relying solely on brain activity but also to reconstruct this route using the memory of the test animal [6]. It's incredible, damn complex, and promising.

Further improvement of the system will make it possible to analyze data with greater accuracy and speed, which will make it possible to understand the principles of the brain, the interconnection of neurons with each other, their reactions to external factors, and compare certain events that occur with the body with the activity of specific neurons, and not parts of the brain as a whole [8].

A brain-computer interface (BCI) system based on real-time functional magnetic resonance imaging (fMRI) and virtual reality feedback has been created by (Ori Cohen et al, 2014). The subjects used their left and right hands and their legs to control an avatar. Finding the regions of interest (ROIs) associated with each of the motor classes and choosing the ROI with the highest average values online form the basis of the BCI categorization. The study takes into account both objective assessments of the individuals' performance on the cue-based and free-choice tasks as well as subjective reports.

When their fingers and toes were free to move, six individuals completed the test with great accuracy, whereas three subjects used just their imaginations to complete the job with high precision. While respondents performed best when the feedback was given 6 s after the trigger in the free-choice test, accuracy in the cue-based task peaked 8–12 seconds after the trigger. They have demonstrated that despite the hemodynamic delay, participants are able to complete a navigation task in a virtual world utilizing an fMRI-based BCI. Other mental activities and different parts of the brain can be addressed using the same strategy.

Identifying Neurodegenrative Illnesses

In order to test cognitive and motor performance in aging and neurodegenerative illnesses, there is now a demand for activities that are interesting, simple to use, and repetitive. (Tobias Nef et al.,2020) assessed whether a maze-like Numberlink puzzle game might be used to examine variations in game-based measures of cognition and motor function caused by aging and neurodegenerative disorders. The Numberlink puzzle game was played at various levels of difficulty by 55 participants, including young people (18–31 years old, n = 18), older people (64–79 years old, n = 14), and the oldest people (86–98 years old, n = 14), as well as people with Parkinson's disease (PD; 59–76 years old, n = 4) and Huntington's disease (HD; 35–66 years old, n = 5). They played the Numberlink puzzle game at various degrees of difficulty while completing usability tests and questionnaires for cognitive, attentional, visuospatial, constructional, and executive function.

Studies of the cognitive (solving time and mistakes) and motor (mean velocity and movement direction changes (MDC)) performance measures used in the Numberlink game showed statistically significant differences between age groups as well as between patients with HD and older persons. Parkinson's disease (PD) sufferers, however, did not vary from older individuals. Significant correlations between game-based movement measures and performance on neuropsychological tests of psychomotor, attentional, visuospatial, constructional, and executive function were found by correlational analyses.

Additionally, the Numberlink puzzle game's many features were successful in achieving graded difficulty levels. The results of this study are consistent with recent claims that information from a maze-like puzzle game might serve as possible "digital biomarkers" for detecting alterations in executive, visuoconstructional, and psychomotor function brought on by aging and neurodegeneration. The Numberlink games' maze-like puzzle-based movement metrics in particular show promise as a tool to track the development of motor impairment in neurodegenerative illnesses.

A key cognitive skill called spatial navigation makes it possible for a person to remain independent by enabling risk-free movement from one location to another. This is one of the initial deficiencies in those with Alzheimer's disease(AD). The Floor Maze Test (FMT), a simple two-dimensional (2D) maze, was used by Marcos (Zanco et al., 2018) to evaluate the spatial navigation skills of elderly people in good health and those with Alzheimer's disease (AD), as well as to identify the cognitive and functional abilities that were related to success on this task.

Deep Slow-Wave Sleep

The brain is still one of the most understudied systems in the world. However, through the efforts of scientists whose imagination in creating new methods of studying it is truly limitless, we will be able to understand more. And the more we know about how the brain works, the better we can influence it. In a good way, of course: diagnosing diseases early, treating advanced brain diseases, etc. In this case, knowledge is not only power but also health.

The patterns of brain activity observed during wakefulness spontaneously appear (reactivate) during deep slow-wave sleep. The reactivation advantage is given to those patterns associated with reward during wakefulness. This was found by Swiss scientists who analyzed the brain activity of 13 people while they slept in an fMRI machine and under EEG control [9]. The article was published in the journal Nature Communications.

Sleep promotes memory consolidation, or, in other words, the transfer of information from short-term memory to long-term memory. This happens when the areas of the brain that are activated during the coding of information in a person in the waking state are reactivated during the subsequent sleep and, more precisely, during the stage of deep non-REM sleep. Moreover, it is known that in humans, reactivation is associated with the appearance of sleep spindle complexes (sigma rhythm) and delta waves (1-4 hertz) characteristic of the stage of deep, slow sleep. At this moment and under these conditions, the brain seems to repeat what has been learned during the day. But it is not yet clear how the brain selects those memories that will be reprocessed during sleep.

Sterpenich of the University of Geneva and her colleagues suggested that, from an evolutionary standpoint, humans should store information that promotes survival, that is, information associated with reward and punishment [9]. And it is more likely that this will have the advantage of reactivation. Observations indirectly support this hypothesis that memory for helpful information benefits from sleep. And to test their assumption experimentally, the scientists conducted a study involving 12 women and six young men (mean age 22.1 ± 2.4 years) [9].

In the early evening, the researchers placed volunteers in an MRI and challenged them to play two games — a 3D maze to find a way out of and a face recognition game in which participants had to find a face from a description [9]. The researchers chose these two games because they are known to activate distinct and well-characterized areas of the brain that specialize in processing information about faces (the fusiform gyrus region and the lateral occipital lobe region) and spatial navigation (the parahippocampal gyrus region). The games were played in 60 blocks in a pseudo-random order with 90-second breaks [9]. Once a person found a solution to one problem, the remaining repetitions of another game were rigged to make it unsolvable. Thus, each participant either won the face game (8 participants) or completed the maze (10 participants) [9].

At the end of the games, the participants remained asleep in the scanner while the researchers recorded their continuous EEG-fMRI data [9]. The participants then went home to sleep and returned two days later to take a memory test. But for further work, only those 13 participants (6 won in faces, 7 completed the maze) who reached the stage of deep, slow sleep were used [9].

First, the classifier was trained to distinguish neural patterns corresponding to the presence (successfully played game) and absence (losing) of reward and activity during the break based on fMRI data during wakefulness. Then it was applied to sleep data.

It turned out that both play-related patterns of neural activity were reactivated rarely and with approximately equal probability in all states from wakefulness to the stage of deep, slow sleep, not including it [9]. In contrast, during deep, slow wave sleep ($p= 0.007$) and high delta activity ($p= 0.03$), the neural activity pattern corresponding to successful or rewarded play dominated compared to the neural activity pattern without reward [9]. For example, if a participant completed a maze and, according to the conditions of the experiment, inevitably lost face recognition. During the deep, slow-wave sleep stage, this person more often reactivated spatial navigation regions than facial recognition regions. And also, the reactivation of spatial navigation regions was more often associated with high delta activity than face recognition regions. And for the winners in face recognition, the opposite is true.

In addition, the occurrence of an activity pattern corresponding to reward play during a sleep session was more often than other patterns associated with activation of the hippocampus ($p \le 0.002$) and ventral tegmental area ($p \le 0.02$). As is known, the hippocampus is an area that plays a significant role in short-term memory and is involved in the processes of memory consolidation, while the ventral tegmental region is in the reward, motivation, and cognition systems [9].

The probability of detecting reactivation separately for each game was also positively correlated with memory productivity (faces: $p = 0.04$, maze: $p = 0.02$) [9]. In other words, the more often the pattern of neural activity occurs in a dream, the better the memory for the game events with which this pattern is associated.

The scholars experimentally confirmed their assumption that the predominantly memorized and therefore reactivated in a dream should be information associated with rewards. Initially, the scholars have made this assumption based on the possible evolutionary significance of such superiority [9]. However, at the end of the experiment the issue of survival did not seem to be as important [10,11]. Nevertheless, sleep is still essential; it helps remember the most important things under the right circumstances. Thus, listening to the same classical music during the study and subsequent sleep helped students briefly improve the memorization of information from the lecture they heard and pass tests on it [12].

Based on data analysis methods and the revealed statistical regularities, dynamic models are developed to describe the processes of generation and propagation of signals in the cellular networks of the brain. Models of interacting neural oscillators can conduct virtual experiments with controlled parameters of dynamic systems.

Discussion and Conclusion

Multichannel activity signals of both the central and peripheral human nervous systems are successfully used to control actuators. New methods of neuro brain activity assessment are being developed and implemented [10]. In contrast to fully robotic solutions, the main advantage of this approach is unlimited brain resources for solving non-trivial tasks, such as coordination of movements, maintaining balance, etc. In particular, when controlling anthropomorphic robotic devices (exoskeleton, exoprosthesis, industrial / gaming manipulator), the user, as a full-fledged participant in the control loop, can independently coordinate and plan the trajectory of movement, removing a significant load on the on-board computer system of the device. This becomes possible due to the involvement of plasticity mechanisms in brain structures (Peyrache & Seibt, 2020)[11]. It is also believed that a biological feedback channel will allow the operator to achieve the effect of "feeling" an external device, which is essential in developing intelligent exoprostheses and even remotely piloted devices.

However, the application of the labirynth as a tool that challenges the mind has demonstrated obvious benefits. These studies have evidently shown that through pushing the individual’s brain, whether it be a rat or a human, one can trigger internal processes that only a NCI can pick up. Only this device, of all invented as of now can explain the peculiarity of the brain activity, when one is performing a difficult task. These studies have all shown that the brain is a network of interacting pulsed neural oscillators. The labirynth is a catalyst that forces the brain to do extra work and activity. Utilizing the information from the above studies, one can not only train the brain, but read the processes going on within it, stimulating it through rewards. To give it a thought, all the studies and experiments have introduced the rewards as a stimulating factor.

The stimulus refers to powerful emotional motivators such as curiosity, passion, and purpose. All of them automatically encourage us to act in one way or another. These are the motivating factors of paramount importance.

Since the journey to the impossible is always tricky, the best of the best never rely on a single source of "fuel" to keep them going through it. And this applies to both physical and psychological "fuel." From the physical aspect, successful and influential people always try to get good sleep, exercise regularly, stay hydrated, and eat right. This is how they "store," accumulate, amplify, and adequately organize everything their body needs to produce energy. However, the correct storage of psychological "fuel" sources is no less critical. To do this, the best of the best accumulate, develop and organize the motivators mentioned above: curiosity, passion, and determination. These sources of psychic power provide them with constant access to all kinds of powerful emotional energy they will need for action.

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