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The Connection of Information Science and Psychology in the Case of the Wisdom Paradox - Part Two

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***Abstract*— *From the beginning, I wrote the article using the nanotechnological process of connecting small parts into several larger assemblies of which it consists. The parts are understood independently of each other, and therefore can be read in any order, and in the article they are given in the following order: Critique of the Modular Theory; The Open-Minded Brain; Genesis of Neurons in Adults; Edelman's Theory of Neural Darwinism (ETND); Stonier's Interpretation and Extension of ETND; "The Psychology of Computers (and Robots)"; The One Hundred Year Study on Artificial Intelligence 2014-2114 – AI100; Information in the Biosphere; Viruses; Semantic Metabolism according to Tom Stonier (1997); Pattern Recognition vs. Logic; Global Information Infrastructure and Automatic Semantic Indexing; Connectome, Connectomics, Bioinformatics; The Human Brain Projects (EU, USA, Japan, China, R Korea, India); and Microbiome or Other Brain. The relationship between the human brain and information technology is complementary. The brain cannot imitate technology, but we try to design the latter in the image and functioning of the brain. As a rule, there are no information-rounded units for a very specific mental operation in the brain. There are networks in the brain that include visual information about a face, auditory information about a name to recognize a certain person, which "reside" in different parts of the cerebral cortex, but are connected into a single attractor. From the first frames and scenes of a film, we immediately know whether we have already watched it. Evolution uses the principle of "less is more". The more advanced and the later they arise in evolution, the less "software" certain regions of the brain are loaded with in advance. The functional organization of the most advanced heteromodal associative cortex, which coordinates the internal states of the organism with the external world, is not modular, but interactive and distributed. Aging-related brain atrophy is asymmetrical and affects the right hemisphere more than the left, as the right hemisphere ages faster than the left. Mental activities stimulate the formation of new neurons and connections between them. When remembering an object, such as a locomotive, it is not a stored image somewhere in the brain. The brain remembers the "locomotive" as temporary patterns of connections. However, new patterns do not create new connections, but rather strengthen existing pathways. The strength of the neural connections that create a pattern is a function of repetition and experience. The meaning of a sentence depends on where we place a comma. If there is no mechanism in our brain to recognize the pattern of the meaning of the comma, we cannot perceive the meaning of the sentence. Computers are machines based on binary logic, while the human brain is an "analog device" with complex circuits adapted to recognize patterns of connections (pattern recognition). There is no sufficiently good and comprehensive theory of how the brain works. Since the advent of computers, we have tried to explain the way the brain works with the help of a computer model. To explain biological phenomena, we use a mechanical model, and conversely, to explain computers, we use a model* *of our brains. In the case of artificial intelligence, we use our nervous systems to sense, learn, reason, and act. In 2014, the Centennial Study on Artificial Intelligence, programs, and policies, and their impact on people, their communities, and society was launched. The »anthropology« of robots and artificial intelligence is developing. Electronic communication systems (Arpanet, Internet, Interspace, etc.) are essential for accelerating the development of our collective intelligence. One of the essential concepts of consciousness is semantic metabolism. Information exists independently of its meaning and must not be confused with the message. The message exists before the meaning and independently of whether the recipients exist or not, but it cannot become meaningful without the recipient, and acquires meaning after being included in the internal information environment of the recipient. Recursive processing of new semantic complexes of information under certain conditions results in the creation of new knowledge structures. The functioning of cellular metabolism as an information processing system is more sophisticated than the information processing performed by a computer, and confirms the giant steps taken by biological sciences in unraveling complex biological systems. Understanding the human brain is one of the greatest challenges of science in the 21st century. To understand how a network transmits information, the type of network, its elements, and its connections must be known. Neural tissue is fundamentally different from the tissues of other organs. The cellular structure of neural tissue and the brain is a genetically inherited product and at the same time a product of experience. In this way, the structure of our nervous systems is personalized! A "map" of synaptic connections between neurons, called a "connectome," is supposed to show the connectivity of synapses and the flow of information in the brain. The convergence between information communication technology and biology was of decisive importance for the launch of human brain projects (in the EU, USA, Japan, China, R. Korea, India). At the end of the second decade of the 21st century, a new science of psychobiotics emerged, revealing the close connection between the brain and psyche with the microbiome, that is, the four-kilogram population of microbes that live in the human intestine. The intestinal microbiome is unique, just like a fingerprint, but the important difference is that we can change our microbiome! Psychobiotics reveals the biological foundations of the connection between the microbiome and health, as well as mental and other disorders.*

***Keywords*— psychology, neuron, brain, neuroscience, computer, network, AI, semantic metabolism, human brain project, microbiome**

Critique of Modular Theory

In the 1980s and 1990s, the notion of "module" was popular in cognitive science and is still popular in some circles today. The term module includes a structurally compact, bounded and informationally rounded unit in the brain for a very specific mental operation, often very complex. Communication between different modules is limited by the fact that there is no overlap between functions or their circuits. Such modules were considered the basic building blocks of systems and the brain.

The modular theory was a kind of "renewal" of phrenology[1]

A public critique of the modular orthodoxy was undertaken by Goldberg. [1] Today, modularity is rejected. The cognitive module is sarcastically called the "grandmother's cell", the neuron where the image of our grandmother is stored. The module is supposed to be "innate". The essence of attractors is that they "emerge". The module is apparently functionally rounded. Different attractors share the same neural components. The module is structurally rounded. The attractor is distributed through a gigantic territory of areas of the cerebral cortex. There must be a network in our head that includes e.g. a visual component containing face information and an auditory component containing name information to recognize a particular person. Despite the fact that these two types of information "reside" in very different areas of the cerebral cortex (parietal lobe for face information and temporal lobe for name information), they are connected to each other in a single attractor. Stimulating a small sub-network of components - neurons (attractor) activates the "story" as a whole. From the first frames and scenes of a film, we immediately know whether we have already seen it. In short, this is the mechanism of general memory!

An open minded brain

The development of modern cognitive science, or neuropsychology, was "paved" by the Russian neuropsychologist Aleksandr Romanovich Luria in collaboration with Lev Semionovich Vygotsky in the

[1] Gr. phren, mind, soul; a disproven doctrine from the 19th century, which deduces from the shape of the skull a person's psychic properties and abilities, was "sold" as a discovery.

1920s. An early interest of Luria was the relationship between culture and the individual spirit, and how the collective knowledge of society becomes the personal knowledge of the individual. Luria called his original approach to psychology "historical-cultural psychology". The main idea of the new discipline was that the cognitive operations of the individual develop to a large extent through the interiorization of various external cultural contents and, above all, how culture in general and language in particular shape the thinking of the individual. Luria found that even the strongest aspects of perception depend on culture. Uzbeks, for example they do not know optical illusions, visible deceptions, which are generally characteristic of members of modern Western societies.

The notion of a culturally shaped mind, introduced by Vygotsky and Luria [2], leads to a very important conclusion for Goldberg's understanding of the biology of the mind: the brain is pre-wired for certain pattern recognition mechanisms, but not for others. This means that the brain must have a huge capacity to store information about various facts and rules. Their nature is not known to us in advance. To this information or knowledge comes by learning through our own experiences or we acquire it from the culture of the collective to which we belong.

Evolution solves this problem by applying the principle of "less is more". Old subcortical structures are pre-loaded with hard-wired information that represents the "wisdom of lineage", and in this way, regions of the cerebral cortex are directly involved in the processing of visual, auditory and tactile senses. The motor cortex is also pre-wired. More complex regions of the cerebral cortex, ti. the associative cortex, contains relatively little previously formed knowledge. Instead, it has a large capacity to process any kind of information so that it can deal in an open-ended way with any conditions of the curve that we can throw the ball in front of the organism.

Paradoxically, it seems that the more advanced certain regions of the cerebral cortex are and the later they were created in evolution, the "less" they are loaded with "software" in advance. Instead, their processing power further realizes the ability to create their own "software" if the needs of survival in an increasingly complex and unpredictable external world demand it. This ability to produce "software" in the form of increasingly complex attractors in turn realizes the "equipment" of new brain regions with the capacity to work with open-ended unfolding of all kinds.

In contrast to the innate pre-wired processors, the hook-like neurons of the visual cortex, the ability of the most advanced regions of the cortex to recognize patterns is called an "emergent property", since they really arise from those brains that are very complex, but also work according to a model very " open-minded".

The evolution of the brain takes place mainly as a gradual transition from a hard-wired to an open-thinking brain with an open unfolding. As a result, the functional organization of the most advanced heteromodal associative cortex, which coordinates the internal states of the organism with the external world, is not like a quilt consisting of various small modules, each of which would be responsible for its own narrow function. The functional organization of this part of the brain is not modular, but highly interactive and distributed. The heteromodal associative cortex develops along a continuous distribution called gradients (Neurons draw energy through the membrane, which is hidden in physical and chemical gradients.), which arise spontaneously, as dictated by the geometry of the brain and the economy of neural networks, but not according to some predetermined genetic or otherwise specified order.

Correspondence between cognitive metrics and brain metrics is exactly what one would expect as an "outgoing property" in a self-organizing brain. Without this derived property, to achieve such a correspondence between cognitive metrics and brain metrics through genetic programming could result in a huge loss of genetic information unnecessarily.

Evolution rejected the non-economic approach and instead created a brain space devoid of innate "information" (tabula rasa), but endowed with a large neural capacity to process the most complex information of any kind and to independently fill it with any informational content.

Neuronal genesis in adults

Aging-related brain atrophy is asymmetric and affects the right hemisphere more than the left, as the right hemisphere ages faster than the left.

Typically, an IQ test has two main components: a verbal (VIQ) and a nonverbal test (PIQ).

The results of the Wechsler Adult Intelligence Scale (WAIS) [2] in neuropsychological tests do not provide the answer that the Performance Intelligence Quotient (PIQ) declines faster than the Verbal Intelligence Quotient (VIQ) with aging.

[2] The Wechsler Adult Intelligence Scale (WAIS) is an intelligence test first published in 1955 and designed to measure intelligence in adults and older adolescents. The test was designed by psychologist David Wechsler, who believed that intelligence was made up of a number of different mental abilities rather than a single general intelligence factor. [3] .

However, today we have direct evidence using neuroimaging methods that the right hemisphere declines faster than the left hemisphere with aging. Thirty years ago, we were sure that the human brain does not regenerate, i.e. that new neurons are not created. The principle was called No New Neurons (NNN)! Today we know beyond doubt that even perfectly healthy people lose neurons with aging both in the neocortex, where general pattern recognition memories are located, and in subcortical structures and around the ventricles, where cavities are found deep inside the brain. The only explanation for the fact that there is no loss of previously acquired knowledge in addition to the loss of neurons lies in the assumption that our memories, especially general memories, are stored in a highly redundant manner.

Today we also know that new neurons are also created in the brain and that the growth of brain structures (hippocampus, which are important for memory) is also influenced by mental activity throughout life. Use promotes the growth of neural structures! Different mental activities stimulate the formation of new neurons in different parts of the brain.

New neurons are not created where they perform their functions, but are produced around the walls of the lateral ventricles as an undifferentiated stem of cells. Then the stem cells differentiate into special types of neuronal cells and these migrate to their final destinations in various parts of the brain, including the neocortex, away from their "place of birth" in the brain. The management of neuronal migration appears to be influenced to some extent by cognitive activity, which determines not only the generation of neurons but also the destination they must go to.

It has been proven that bilingual people have significantly more gray matter in the left angular gyrus than people who know only one language.

Bilinguals also have higher white matter density in the left hemisphere. White matter consists of long myelin tracts in the role of connecting distant cortical regions. Additional cognitive activity also encourages the growth of distance-connecting pathways. This is no less important, since the complex functions of the brain arise from multiple interactions between a huge number of neurons, adjacent and distant from each other, and such interactions are mediated by pathways between neurons. Bilingual people also have a higher density of white matter than people who know only one language, even in the right hemisphere. This discovery suggests that the right hemisphere plays a role in second language learning. Brain development as a result of mental activity is not limited to youth and continues much later in life.

Heschl's gyrus, which is essential for processing sound, is twice as large in musicians as in non-musicians. Juggling experiments have shown that neuron production occurs even within a relatively short period of three months. An MRI of the brain before and after three months of training showed that white matter had grown in the temporal lobes of both hemispheres and in the parietal lobe of the left hemisphere.

There is ample evidence that old people can remain functionally and cognitively healthy, despite the neuropathological signs of Alzheimer's disease and other dementias. Neuronal protection from lifelong mental activity (extra neurons and connections between them) is sufficient to prevent the effects of dementia-induced brain damage and to maintain a healthy mind despite the presence of biological markers of the disease. Wisdom increases with age. Aging is the price of wisdom! [4]

Edelman Theory of Neural Darwinism (ETND)

According to Edelman's theory of neural Darwinism (1987 [5], a similar process of the formation of diverse connections and their selection based on external stimuli should take place in the population of nerve cells, as is the case for the population of antibodies. He rejected the image of the brain as a computer and focused on the dynamism and plasticity of the brain.

In 1981, he founded the Neurosciences Institute (NSI) in San Diego, USA, for research in this field.

Edelman's Theory of Neural Darwinism (ETND) [5] [6] [7] includes the following ideas and concepts:

1. During the development of the embryo, an extremely complex neural network (NN) is formed, which represents the primary anatomy of the brain.

2. Learning involves the "superimposition" of connection patterns on the NN. Connection patterns are created by strengthening existing paths, not new connections or increasing the number of connections!

3. Routes compete with each other! Association patterns are "fed" by stimuli and incentives. Stronger connections grow at the expense of weaker ones, which collapse and override. Connections disappear, not neurons!

Individuals in social networks are connected by either "strong" or "weak" ties. In the modern liberal and technological society, some "weak" links have become stronger than "strong" ones. [8] Love belongs to weak connections, the institution of marriage to strong connections. The connection of the social community of man and woman, based on love as a connection, is stronger than marriage as a strong connection.

Ecclesiastical and civil marriage, despite the fact that it is supposed to be a strong and indestructible connection forever, falls apart without love, but the love connection is very permanent. Connections in brain and computer NNs belong to the so-called weak connections, which today are the basis of a stronger connection between people.

Stonier's interpretation and extension of ETND

According to Stonier's extended ETND [7], cellular adhesion molecules (CAM) determine which cells will approach. In this way, localized areas in the brain - the main brain substructures - are formed. The substructures include all the centers that analyze and encode sensory stimuli (inputs) and motor reactions (outputs). An infinite number of connections are formed within and between brain structures, forming an incredibly complex neural network. It is the primary architecture of the brain at birth, which is formed during embryonic development (embryogenesis). The combinations of genetic and epigenetic[3] factors that determine connections (synapses) are very complex. Their microstructure is infinitely differentiated and unpredictable [4], while the macrostructure within the synapses in each individual of the same species is the same!

Stonier [7] explains that in the memory of an object, such as e.g. locomotive, it is not a visual image stored somewhere in the brain, similar to a snapshot (photo) or slide, nor an encoded version of the image, such as an image stored on an optical disc or a pattern of on/off switches. The brain remembers the "locomotive" as temporary patterns of associations and processed experiences that are connected to other related patterns along the brain. A strong enough sample can have a lifetime "shelf life"! But the strength of such a pattern must be renewed, otherwise learned patterns decay over time, unlike genetically inherited patterns.

Learning involves "loading" patterns onto the neural network. However, new patterns are not created by new synapses or more of these synapses (connections), but rather by the strengthening of existing pathways.

The idea that the learning process is based on changes in the transmission strength of synapses and that these changes form the basis of memory was already known at the beginning of the 20th century [9], but only Bliss and Lomo [10] proved this hypothesis in rabbits. [7] They found that rapid, repetitive activation of certain neural pathways in the hippocampus (part of the brain) of rabbits causes an increase in the transmission strength of synapses, which can last for several days or even several weeks.

The growth of the transmission power of synapses, which lasts for a long time, is called "long-term potentiation" (LTP). LTP represents the most likely explanation of the cellular mechanism of memory and learning.[5]

The strength of neural connections that creates any pattern is a function of at least two processes: repetition and experiences that are so important to the organism that they are imprinted in the brain for life in response to a single event. These include experiences associated with great danger or great pleasure.

Events that lead to certain situations and actions are stored in memory. It is established that the increased involvement of the limbic system (hypothalamus) at the time of the event - allegedly caused by changes in hormonal states - affects better storage of the event.

The juxtaposition of objects and events, which leads to a dangerous confrontation that causes fear, is stored by the individual as patterns of connections. A form of wisdom to "sniff danger in advance" also consists of such connection patterns!

Stonier also explains the failure of patterns if they are not strengthened as much as they should be!

[3] Epigenesis, a biological theory that in personal development an increasingly complicated organism develops from a simple initial state.

[4] At birth, neither twin has the same brain architecture.

[5] Part of the mechanism involves the release of the amino acid glutamate as an excitatory transmitter along synapses. This activates certain chemical receptors. One of them, called the NMDA (N-methyl D-aspartate) receptor, causes an influx of calcium ions into certain parts of the nerve cell (dendritic spine or spine). An increase in the concentration of calcium ions is essential for the LTP process. High calcium concentrations most likely trigger the activation of certain proteins. [9]
The protein "MAP2" (microtubule-associated protein) is important for the formation of new neural pathways.
MAP2 is not normal in the degenerating neurons of Alzheimer's patients. MAP2 helps determine the shape of the neuron. It is concentrated in dendrites. There is good evidence that MAP2 is responsible for dendritic branches. Dendrites resemble a tree. Two dendrites from two different nerve cells fit like the fingers of a hand without touching each other. It's a synapse. How MAP2 will behave is governed by the protein's phospholylation and dephosphorylation (the addition and removal of phosphorus groups). This is probably why the influx of calcium ions is so important. Neuron activity controls this process via glutamate and NMDA receptors. MAP2 molecules are responsible for strengthening the connections of neurons along the active pathway.

As mentioned, Edelman introduced the concept of neural competition. Each nerve or cluster of nerves can participate in any one of thousands of patterns, just as a letter or word can participate in any one of thousands of sentences. Connections are made, not neurons themselves. According to Edelman's theory of neural Darwinism, the fittest network survives, i.e. network selected by brain activity.

But not only do we admire the simplicity of the brain – its adaptability and efficiency in learning to recognize complex patterns of connections – but we are also aware of its weaknesses, such as the superstition that a black cat brings bad luck.

(1) Ibis, redibis, nunquam peribis in bello.

It is, "You shall go, you shall return, you shall never fall in war." Another option is just the opposite:

(2) Ibis, redibis nunquam peribis in bello.

It is: "You will go, you will never return, you will fall in the war."

The meaning of these sentences depends on the place where we put the comma. A similar situation, although less critical, also occurs inside our brain. If there is no mechanism in our brain for recognizing the pattern of the meaning of the comma, we cannot perceive significant differences between the meanings of these sentences. [11]

Edelman's neural Darwinism also applies to machine intelligence.

Neural network (NN) computers represent a natural step in the evolution of machine intelligence. In NN, it is possible to change the strength of connections between units, which includes collective intelligence. The change in power is either positive or negative.

Most of human intelligence does not come from the brain's ability to reason using logic, but primarily from the ability to make inferences using the memory of connection patterns. Computers are machines based on binary logic, and the human brain is an analog "device" with incredibly complex circuits adapted to recognize patterns of connections.

"Th Psychology of Computers (and Robots)"

The further development of computers would not be possible without "computer psychology"!

Mental phenomena with thinking have an anatomical and physiological basis, and if computers are machines that "think", then their "thinking" should be the subject of "computer psychology" with its "anatomical" and "physiological" basis.

The main differences in the "anatomy and physiology" of classical computers and the human brain [7]

Computers	Brain
1. Digital information processor based on circuits of binary witching	Analog information processor, which includes complex neural system with a multitude of chemical neurotransmitters and modifiers
2. Information is transported as electron pulses through conductors and semiconductors	Information is transported as pulses depolarizations through membranes and as neurotransmitters through synapses
3. Impulse transmission speed 10^{10} cm/sec	The impulse transmission speed is approx 10^{3} cm/sec
4. Relatively simple circuits, the complexity of which increases	Extremely complex circuits: 10^{11} neurons with more than 10^{15} connections
5. Extremely stable crystal structures	Biological tissues sensitive to damage
6. Can work in different conditions.	They need a carefully arranged environment to work
7. The computer system can shut down endless times without any damage	The brain needs continuous energization with intention to the maintenance of a living system
8. They are not self-renewing. Some self-	Tissue is capable of significant self-

repairs and bypasses of damaged function areas to other circuits	reconstruction. High transfer capacity
9. Memory based on binary switches	Memory based on neural patterns connections

There is definitely no sufficiently good and comprehensive theory of how the brain works. After the advent of computers, attempts are being made to explain the way the brain works with the help of a computer model.

In order to explain the biological phenomenon, we used a mechanical model.

If we apply the model of our brain to computers, we can think of ROM (read-only memory) as patterns of instinctual behavior that are innate, RAM (random-access memory) as patterns that are included in learning patterns. An intermediate behavioral pattern such as imprinted information in higher vertebrate animals can be thought of as PROM (programmable read-only memory). The evolution of the brain in higher mammals can be imagined as a growth in the number of ROMs and PROMs, and this growth is followed by an even faster growth of RAMs. [12] [7]

Centennial study on artificial intelligence 2014.-2114. (The One Hundred Year Study on Artificial Intelligence, AI100)

Artificial Intelligence (AI) is a science and a type of computer technology inspired by the ways humans use their nervous systems and bodies to sense, learn, reason, and act.

The classification scheme (Knowledge Map) of the field of AI includes:

• search and planning, which deal with goal-oriented behavior; search plays a key role, for example, in chess-playing programs like Deep Blue, and in deciding which move (behavior) will ultimately lead to victory (goal);

• knowledge representation and reasoning, which includes processing information (usually in large quantities) into a structured form for more reliable and efficient inquiries;

• machine learning as a paradigm that enables systems to automatically improve their performance by observing relevant data;

• robotics, which investigates the fundamental aspects of perception and action - and especially their integration - which enable the robot to behave effectively; because robots and other computer systems share the living world with human beings, a special thematic field of interactions between humans and robots (human robot interaction) has emerged in recent decades;

• machine perception, which has always played a central role in artificial intelligence, partly in the development of robotics, but also as a completely independent field of study; the most frequently studied methods of perception are computer vision and natural language processing;

• several other areas in AI that are consequences of the growth of the Internet; social network analysis examines the influence of neighborhood relations on the behavior of individuals and communities; "crowdsourcing" is an innovative problem-solving technique that relies on harnessing human intelligence (typically thousands of people) to solve difficult computing problems.

In the eighteenth century, Thomas Bayes [13] provided a framework for inferring the probability of events. In the nineteenth century, George Boole [14] showed that logical reasoning, dating back to Aristotle, could be done systematically in the same way as solving a system of equations.

At the turn of the twentieth century, advances in the experimental sciences led to the emergence of the field of statistics, which enables inferences based on data. The idea of engineering a machine to execute sequences of instructions, which captured the imagination of pioneers such as Charles Babbage, matured in the 1950s and enabled the development of the first electronic computers. [15] By then, even primitive robots were built that could feel and act independently. [16]

The most influential ideas on which computer science is based come from Alan Turing, who provided the formal model of computing. In the classic essay Computing Machines and Intelligence, [17] introduced the possibility of computers simulating intelligences and identified many of the components now associated with artificial intelligence, including how intelligence can be tested and how machines can learn automatically. Although these ideas inspired AI, Turing did not have access to the computing resources necessary to turn his ideas into action.

The field of artificial intelligence (AI) was officially born and christened at a workshop held in 1956 by John McCarthy at Dartmouth's Summer Research Project on Artificial Intelligence. The goal was to explore ways in which machines could be made to simulate aspects of intelligence, an idea central to the field. In the proposal he wrote for the workshop with Marvin Minsky, Nathaniel Rochester and Claude Shannon, McCarthy is credited with the first use of the term "artificial intelligence". [18] Many of the people who soon became involved led important AI projects, including Arthur Samuel, Oliver Selfridge, Ray Solomonoff, Allen Newell, and Herbert Simon. [19]

Between the 1950s and 1970s, several core areas emerged in the AI effort. [20] Newell and Simon worked to develop an efficient procedure for finding solutions in large, combinatorial spaces. In particular, they used this idea to construct proofs of mathematical theorems, first with the logic theorist program and then with the help of the General Problem Solver. [21] In the field of computer vision, the early work of Selfridge and colleagues [22] in character recognition laid the foundation for more complex applications such as face recognition. [23] In the late sixties of the twentieth century, work also began in the field of natural language processing.[24]

With the "Shakey" robot on wheels, the first general-purpose mobile robot, year of creation 1966, built by SRI International (Stanford Research Institute), mobile robotics began. Samuel's program for playing checkers (1959) [25], improved by self-play, was one of the first working examples of a machine learning system. Rosenblatt's Perceptron computer model [26], based on biological neurons, became the basis for the field of artificial neural networks. Feigenbaum and Buchanan [27] advocated the development of expert systems - knowledge repositories tailored to specialized fields such as chemistry and medicine.

In the 1980s, despite the fact that the progress of various aspects of artificial intelligence was promising, the field could not boast of significant practical successes. The gap between theory and practice was partly the result of insufficient emphasis on the development of physical systems with direct access to environmental signals and data. There was also too much emphasis on Boolean logic (True/False) and overlooking the need to quantify uncertainty. These shortcomings were not recognized, and by the mid-1980s, interest in AI began to wane and funding disappeared. This period is referred to by Nilsson [28] as the “AI winter”.

The revival in the 1990s was based on the realization that "good old AI" was inadequate as an end-to-end approach to developing intelligent systems. [29] Instead, it is necessary to develop intelligent systems from the ground up ("bottom up manner"). The new AI is based on the physical grounding hypothesis. [30]

Technological advances have also made the task of building systems driven by real-world data more feasible. Cheaper and more reliable sensing and actuation hardware has made robots easier to build. In addition, the capacity of the Internet to collect large amounts of data and the availability of computing power to store and process data has enabled statistical techniques to be extracted from data. All this has enabled the development of AI in the last two decades and the great impact of AI on everyday life.

In 2014, the Centennial Study on Artificial Intelligence [19] and its impacts on people, their communities and society was launched.

The centennial study builds on an earlier effort known informally as the "AAAI Asilomar Study." Between 2008 and 2009, Eric Horvitz, then president of the Association for the Advancement of Artificial Intelligence (AAAI), assembled a group of AI experts from multiple institutions and fields, along with scholars in cognitive science, philosophy, and law. Working in divided subgroups, participants addressed short-term AI developments, long-term options, and legal and ethical concerns before gathering for a three-day meeting in Asilomar to share and discuss their findings. A short written account of the intensive discussions at the meeting, supplemented by subsequent discussions of the participants with other colleagues, generated widespread interest and discussion in the field and beyond. The impact of the Asilomar meeting and the significant advances in artificial intelligence, which included AI algorithms and technologies that began to enter everyday life around the world, prompted the idea of a long-term iterative study of artificial intelligence and its impact on humans and society. [31]

The study includes the science, engineering and application of computer systems for AI. The Centennial Study is overseen by the Standing Committee, which appoints a Study Panel every five years to assess the current state of AI. The Study Panel reviews the progress of AI in the years since the previous report, predicts potential progress in the coming period, and describes the technical and societal challenges and opportunities that progress brings, including in areas such as ethics, economics, and the development of systems compatible with human cognition. The main purpose of the periodic peer review of research as part of the Centennial Study is to collect and link the results of research on AI and its impacts. Syntheses and evaluations are expected as the basis for directing research, development and design of systems, as well as programs and policies for their use for the general benefit of individuals and society.

In 2016, the first report was issued as part of the Centennial Study. The Study Panel consisted of seventeen experts in the field of AI from academia, corporate laboratories and industry, as well as scientists from the fields of law, political science, politics and economics. Panel members were from a variety of specialties and geographic regions, genders, and career stages.

In 2021, the second report of the Study Panel on the progress of the AI100 project "Gathering Strength, Gathering Storms: The One Hundred Year Study on Artificial Intelligence (AI100)" was published. [32]

The anthropology of robots and AI is also developing. Man is a creature of tools, and man's main tool is man himself as a slave (Aristotle), as a serf and as a worker. A robot is also replacing man as a slave in modern society.

In the case of man as a tool, it is the objectification of people and the dehumanization of man.

Some of us today live in fear that humans will be replaced by artificial intelligence and robots. In order to reduce labor costs, the use of robots is increasing in developed modern society with the aim of increasing efficiency and profit. Modern capitalist society is organized on the basis of ownership, and property and profit are of primary importance. The functioning of society should be understood holistically, as it includes economic, political, legal and moral aspects in addition to technological aspects. The marketing and use of robots must be regulated by law with the aim of preventing dehumanization caused primarily by social robotics and the use of robots as persons, companions and sexual partners. [33]

Stephen Hawking has made no secret of his fears about the possibility of thinking machines one day taking over society. He went so far as to predict that the future development of AI will spell the end of the human species. However, Hawking's attitude towards artificial intelligence was much more complicated. He was deeply concerned by superhuman artificial intelligence (AI), which is capable not only of reproducing the processes of human intelligence, but of further expanding them without human will. Hawking warned of an extreme form of artificial intelligence, in which thinking machines independently change themselves and independently design and build increasingly capable systems, and humans, whose pace of biological evolution is very slow, would be able to drive off the planet Earth. [34] [35]

The realization that the ability to learn is crucial for the intelligence of a system was decisive for the development of artificial intelligence in a new direction!

Individual new computers are not only capable of answering knowledge-based questions as a result of learning, but also have the capacity to create knowledge. [36] Thanks to the genius of "knowledge engineers" who create rules by which computers reorganize information, computers create new knowledge structures while processing information. Solving a chess problem requires intelligence and knowledge, but solving a problem in a new and unique way requires creativity as a higher form of intelligence.

The initiators of the development of artificial intelligence 60 years ago planned to develop the ability to think as the essence of intelligence, "common sense".

Adaptive machine learning is based on the idea of teaching a computer system to behave intelligently based on a huge amount of data. [37] Even a decade ago, this development was not possible because there was not enough data to learn from, nor enough computing power. Computers detect patterns in data, then look for differences in the patterns and process them.

However, the development of the last few years is more appropriately described as progress in statistics, rather than artificial intelligence itself [38]

Although machine learning technologies enable the automation of many tasks, data analysis and the search for patterns, machines do not know that e.g. they are playing chess because they are unconscious. But just because no one knows how to get machines to think rationally doesn't mean it's not possible and it's only a matter of time. Computers are improving exponentially, smarter machines are designing even smarter machines to be able to shape electrical signals and biochemical changes like in the brain. Will another way be invented to create intelligence with no similarity to the biological brain, and the possibility of HAL type computer intelligence surpassing human is definitely greater than zero!

[39]

Decisions arise from processes in a continuum from automatic, i.e. "hardwired", congenital or instinctive, fast (overlearned, overlearn, to continue studies or practice after obtaining a professional education), but relatively inflexible intelligence, to controlled, less fast and less efficient, but more flexible intelligence. Adaptive intelligence is central to human cognition and plays a key role in our ability to change the world according to need. Reliance on controlled information processing is sometimes increased within a population due to its benefits. The automatic mode and the analytical mode of thinking alternate cyclically. The agents of the theoretical model of the evolutionary game differ according to the use of automatic and controlled processes. Within a wide range of parameters and model assumptions, cycles appear in which the prevalence of a particular type of treatment in the population fluctuates between two extremes. Controlled intelligence often creates conditions that lead to its own demise and the growth of automaticity, thus undermining the progress made with the emergence of controlled processing. This realization is important for understanding similar cycles in human history and for insight into the circumstances and challenges facing our species. [40]

In the Internet age, information about the source of information and how to get it (ie referral and reference information) is important, while the need for memory recall is little or no. As long as we know where the information is and how to access it, we really don't need to recall the memory. The Internet acts as an external memory unit where information can be retrieved anytime and anywhere. Before the Internet, other technologies, including books, were available for these needs. [41]

It is not to be expected that through education we would learn to use an analytical way of thinking, as we generally rely more on emotions than reason when making decisions. [42]

Tainter is known for his theory of declining productivity of innovation and technological pessimism - the problems of natural resources can no longer be solved with the help of technological innovations of low productivity. The integrity of modern society, which is the most complex society in history, is in disarray, as a state of collapse has been reached, when there are no more marginal returns invested in technological innovations. [43]

Gullible technological optimists proceed from the assumption that the productivity of innovation in history is either constant or even increasing.

The threat that computers will replace human work and devalue it is already a stereotype. [44]

Ray Kurzweil predicted that by l. 2045 billion times increase the intelligence of human machine civilization and the result will be a technological singularity that is difficult to imagine and predict, hence the term "singularity"! The technological singularity occurs when artificial intelligences surpass human beings as the smartest and most capable life forms on Earth and will erase the distinctions between humans and machines. [45]

If artificial intelligence is used narrowly, the instability caused by economic inequality in society will only intensify. If Silicon Valley is taken over by members of the poor 99 percent armed with pitchforks and axes, we will not experience superintelligence. [38]

Information in the biosphere

In the same way that images "flash" through our brains, they can also "flash" through the outside world from computer to computer. Computational collective intelligence, which is rapidly evolving, is similar to the billions of connected neurons in our brains.

Electronic communication systems (ARPANET, Internet, Interspace, ...) are key to accelerating the development of our collective intelligence, as the ultimate purpose of networking is to enable interconnected computers to interact in an intelligent manner.

Global computer networks are said to be a mixture of human and machine collective intelligence - the noosphere (thinking sphere) as the final result of the biosphere's efforts towards "cerebralization", as an extension of the biosphere. Teilhard de Chardin [46] was convinced that the correct interpretation of new achievements of science and thought does not lead to materialistic but to spiritual evolutionism. The world as we know it does not develop randomly, because it is structurally managed by a personal center of universal convergence towards the Omega point.

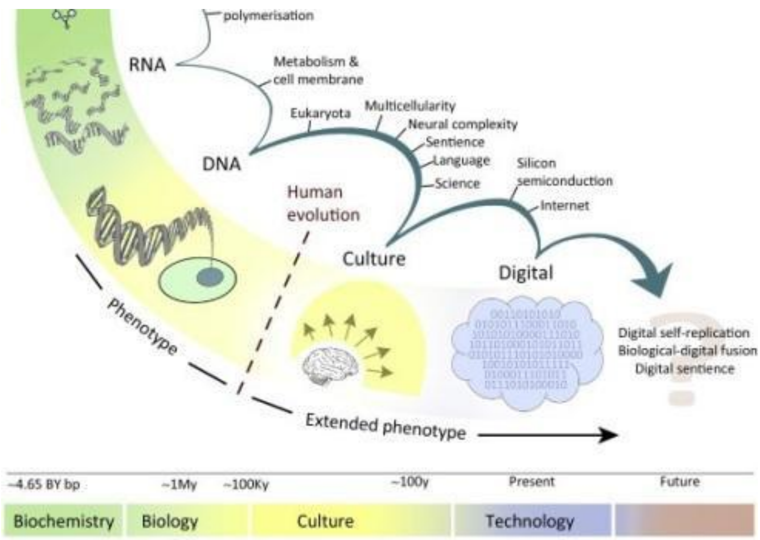


Fig.1: Information in the Biosphere [47]

Clarifications for understanding the present model

Polymerization is a chemical reaction where many smaller molecules called monomers form a polymer. Monomers are mostly organic unsaturated compounds. Monomers of the same type can react with each other, in which case we are talking about homopolymers, or the monomer molecules are different and so-called copolymers are formed.

Eukaryotes (scientific name Eukaryota) are organisms that are built by eukaryotic cells or eucites.

There are two major groups of organisms on Earth: prokaryotes and eukaryotes. The difference between these two types of life is very large, although both are based on the same molecular biological foundations, more precisely: in both cases, the basic unit of life is the cell, which is composed of the same group of organic macromolecules (proteins, sugars, lipids and nucleic acids), which is involved in the same basic biochemical processes. The most obvious difference between prokaryotes and eukaryotes is at the level of cellular organization and structure, the eukaryotic cell being much larger and more complex than the prokaryotic one. Furthermore, eukaryotic organisms can be multicellular, while prokaryotes are only unicellular. Eukaryotes are practically all plants and animals, while prokaryotes are bacteria and archaea.

Sentience

A digital organism is a computer program capable of self-reproduction, mutation and development. Digital organisms are used to test specific hypotheses and mathematical models of evolution. The study of digital organisms is closely related to the field of artificial life.

The distinction between genotype[6] and phenotype[7] was proposed in 1905 [48] in order to make a clear distinction between heredity and the actual expression of the inherited.

DNA and RNA are types of nucleic acid. DNA stands for deoxyribonucleic acid, RNA stands for ribonucleic acid. DNA is double-stranded, while RNA is single-stranded.

We have both DNA and RNA in our bodies. We need them both. DNA is a blueprint; it contains all the instructions for the cell to grow, function and replicate. The RNA executes these instructions; copies and transfers the genetic code from DNA to ensure that the appropriate proteins are made. "DNA makes RNA, which makes proteins." [49]

Big Data requires a big vision of big changes. Data is based on what happened in the past, and on this basis we are able to predict a future that is similar to the past. Because expectations relate to the future, which is supposed to be better than the past, in order to predict the future, which is not in the data and which has not yet existed, in addition to big data, we also need modern digital tools for creating theoretical models. [50]

Scenarios, fusion, replacement

Evolution has transformed life through key innovations in the storage and reproduction of information, including RNA, DNA, multicellularity, culture, and language. The carbon-based biosphere created humans as cognitive systems capable of developing technology, the latter of which will lead to a comparable evolutionary transition. Digital information has reached a volume of information similar to that in the biosphere, which continues to increase exponentially. Like previous evolutionary transitions, the potential symbiosis, the fusion, between biological and digital information will reach a critical point when these ciphers are able to compete with natural selection. The model only includes this fusion scenario! However, the possibility that this fusion would create a superorganism that would use a low-conflict division of labor to perform information tasks is equally likely. [47]

The growth of non-biological computing information processing power is exponential and shows no sign of abating. According to Kurzweil's technological singularity scenario, cybernetic brain implants allow humans to merge their brains with artificial intelligence. He predicts that by the middle of the 21st century, the distinction between biological and non-biological machines will actually disappear, as the fusion scenario will come to fruition. At the Machine Intelligence Research Institute (MIRI), formerly the Singularity Institute for Artificial Intelligence (SIAI), they envision a combination of Moore's Law and intelligence based on recursive self-testing software. The explosion of intelligence will result in an era of non-biological superintelligence. [51] Biological humanity is already facing replacement by artificial intelligence, not fusion. [52] This more apocalyptic replacement scenario was sketched out by AI researcher Hugo de Garis. De Garis predicts a "giga" war between ultra-intelligent "artificial intellects" and archaic biological humans in the course of this century. Superintelligent devices will triumph and continue to colonize space without humans. [53] [52] [35]

[6] Genotype -a m (î) biol. the set of all genes of an organism, heritable mass

[7] Phenotype -a m (î) biol. external and internal properties and characteristics of the organism

We know that we are based on direct reflection on self-esteem [54]

Legal bans on empirical methods in consciousness research in relation to risks to human health are a major obstacle to scientific knowledge of this difficult issue. The obvious question is whether a posthuman superintelligence will reach the level of "self-awareness". For now, we can listen to Einstein's famous statement: "What does a fish know about the sea in which it swims?" Shouldn't self-confidence be a condition for the perfect functioning of machine superintelligence!? [55]

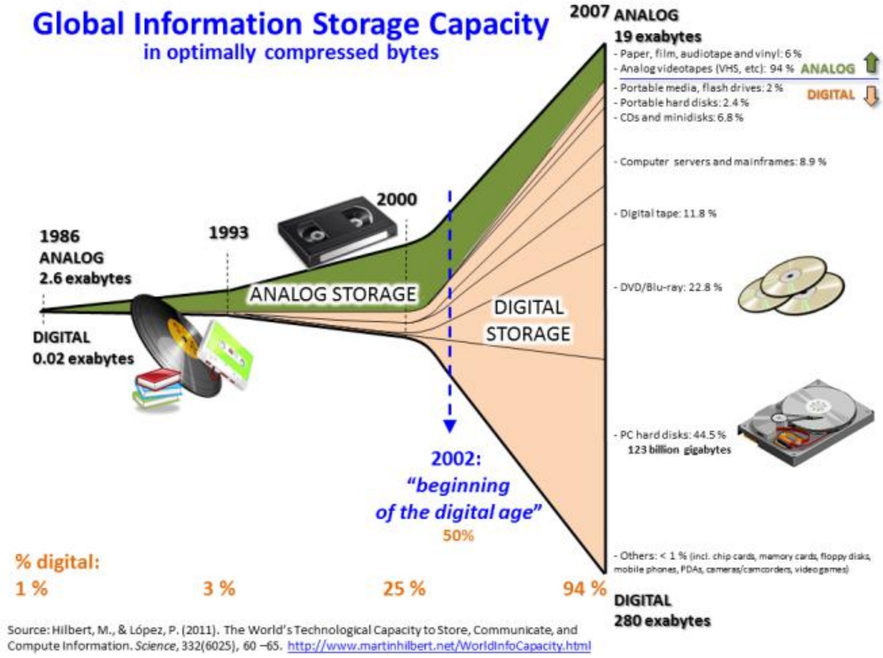


Fig.2: Year 2002 - the beginning of the digital age [56]

Before the digital revolution, information stored on analog video tapes such as VHS tapes, long-play records, and analog audio tapes dominated. Until the year 2000, digital storage did not make a significant contribution to technological memory, contributing 25% of the total in 2000. Hard drives accounted for the largest share of storage in 2007 (up to 52%), while optical DVDs contributed almost a quarter (23%) and digital tapes about 12%. Hilbert and Lopez (2011) [56] estimate that the year 2002 is the "beginning of the digital age" - the moment when the human species for the first time stored more information in digital than in analog devices. They estimated the technological capacity of general-purpose computers for information storage, communication and processing based on monitoring 60 types of analog and digital technologies in the period 1986 - 2007. General-purpose computer capacity grew at an annual rate of 58%. Capacity for two-way telecommunications increased by 28% annually, which closely followed the increase in globally stored information (23%). The capacity for one-way dissemination of information through broadcast channels had a relatively modest annual growth (6%). Digital technologies have dominated telecommunications since 1990, in 2007 99.9% of them were in digital format, half of technological memory is in digital form since the beginning of 2000, and in 2007 it was 94%.

Viruses

Just as biological viruses are integral parts of the biosphere, computer viruses, as one form of "pure information", are integral parts of the noosphere.

Computer viruses are the informational equivalents of biological viruses and as such are supposed to be true artificial intelligence!

Biological viruses are capable of learning as they reproduce and mutate. All biosystems that exhibit the capacity to change behavior as a result of experience, i.e. learning, should be classified as intelligent systems.

Computer viruses represent an entirely new type of intelligent entities that are admittedly man-made, but are capable of analysis and intelligent responses that include both the ability to survive and self-replicate within the informational content of the computer environment as their host.

Intelligent responses result in one of the following three states:

• the system is capable of its own survival;

• the system is capable of its own reproduction;

• the system is goal-oriented and capable of achieving the set goals.

However, computer viruses represent a form of meta-intelligence that cannot be classified as machine intelligence, even though they were created by humans within machine intelligence and are completely dependent on it.

Once man creates them, they are no longer dependent on him and are capable of self-reproduction. As "pure information", they are capable of growing within the pure information provided by machine intelligence, as well as mutating and adapting to this information environment.

Semantic metabolism according to Tom Stonier [57]

Friedrich Wöhler, a German chemist (1800-1882), is considered the originator of organic chemistry. In 1828, with the synthesis of urea, he proved that organic compounds can be formed from inorganic compounds also artificially in the laboratory, without the influence of the "life force" (élan vital) of living organisms, as had been the case until then, and thus established the scientific field of metabolism in the human body. This was the first of many blows against the beliefs and theories that life as a phenomenon involves either some supernatural force or God as creator.

Pieces of information entered into the brain are switched and recycled through various existing knowledge structures in a way called semantic metabolism.

The Western scientific tradition differs greatly from the Eastern tradition in its attitude to consciousness, but both agree that there are different states of consciousness.

The internal information environment in our brain changes a lot depending on states of consciousness. The brain in sleep and dreams is very different from a hypnotic trance state or drug-induced hallucinations.

With changes in the internal information environment, the meaning of information also changes.

Meaning and consciousness are completely different phenomena.

Expressing meaning does not require intelligence, whereas intelligence is a condition of consciousness. Meaning does not need consciousness, but consciousness necessarily includes the meaningfulness of information, which is then processed in the internal information environment of an advanced brain. A less developed brain does not allow the emergence of consciousness, but only primitive forms of consciousness.

The brain and consciousness have an evolutionary history. Consciousness does not develop as an all-or-nothing property of developing intelligence.

Consciousness, as well as intelligence and understanding (of meanings), represents a spectrum of phenomena, both from the point of view of phylogenesis and ontogenesis of an infant into a child and then into an adult. Around 18 months of age, there is a shift from the use of experiential representations to the use of hypothetical representations that refer to a possible reality. This developmental shift allows children to plan for the future and make inferences about the future based on the past, sometimes without perceptible evidence. Brain damage can return an adult to an infantile state of consciousness.

Consciousness cannot be considered as a single concept, but we can talk about different types of consciousness. But if we consider consciousness as a single concept, it is more appropriate to consider it as a cluster concept, similar to the concept of health. [58]

To explain meaning as a result of message processing, it is better to use the paradigm of the internal information environment of cells rather than the computer model.

The most important messages of meaning within cells are sent by DNA, which is the biochemistry of meaning at the cellular level. If two cells are exposed to the same chemical messenger, they will most likely respond differently, depending on the recipient's internal informational environment.

The phenomenon of biological symbolism and the model of hormonally mediated communication between cells was given by Gordon Tomkins. [59]

It was about the use of semiotics in biology - biosemiotics.

According to R. Corriden and P. A. Insel [60], cells release adenosine triphosphate (ATP), which activates P2X[8] and P2Y receptors localized on the plasma membrane, thereby modulating cell function in an autocrine or paracrine manner[9]. The release of ATP and subsequent activation of P2 receptors helps establish a basal level of activation (sometimes referred to as a "set point") for signal transduction pathways and regulates a wide range of responses that include tissue blood flow, ion transport, cell size regulation, neuronal signaling, and host interactions. and pathogens. Basal relaxation and autocrine or paracrine

[8] Power-to-X (also P2X and P2Y) is a multiple electricity conversion, energy storage and re-conversion pathway that uses excess electricity, typically during periods when fluctuating renewable energy production exceeds load..

[9] The main difference between autocrine and paracrine mode is that autocrine factors act on the cells that produce them, while paracrine factors act on cells that are in close proximity to the cells that produce them.

responses to ATP are multifunctional, evolutionarily conserved, and provide economical ways to modulate cell, tissue, and organismal biology.

Information exists independently of its meaning, and this is the sine qua non of information science. Meaning is the result of processing information and placing it in context. A bacterial cell interprets the message encoded in DNA, the brain interprets the message encoded in the received information.

The information must not be mixed with the message!

The message acquires meaning after being integrated into the recipient's internal information environment. Determining meaning is a two-step process that involves analyzing input information and selecting information with and without meaning. Meaning is a state achieved by integrating input information into information structures that already exist in the host. This semantic complex "message-context" can be informationally processed in advance. Advanced information systems such as our brain first deal with the original semantic complex, even if it is an internal message coming from our body. This enables a second "message-context" complex, which is a mixture of the original semantic complex and the secondary context. Through repetition, a hierarchy of contexts is created that creates understanding if sufficient processing is done. More and more information is stored in the brain and the brain reorganizes it into new patterns.

The recursive processing of new semantic complexes of information under certain conditions results in the creation of new knowledge structures.

Simple decoding of the message does not require intelligence. The radio decodes the received electro-magnetic radiation and converts it into sound waves that can be detected by the listener, since the simple electronic circuits of the radio cannot be attributed intelligence. Decoding is a mechanical process that is not yet an understanding of meaning. In order for the message to become meaningful, the contained information must be integrated into the recipient's internal information environment.

Meaning as intelligence is a spectrum of phenomena. At one end of the spectrum is the purely mechanical process of crystal growth by selecting a suitable atom or molecule from a mixture of substances. The next stage is represented by enzyme molecules that select a specific set of substrate molecules. Enzyme molecules are governed by control mechanisms that activate or inhibit their tasks. It is about information processing. Such externally triggered information processing, necessary for the coordination of cellular metabolism, results in structural changes in the enzyme molecule. This means that the internal informational environment of the protein can change.

If the inhibitory message changes the resonance structure of the enzyme molecule to the extent that it inhibits the enzyme, it will no longer choose substrate molecules among others in its environment. The enzyme's internal informational environment can no longer provide context for the substrate molecules and they will lose any "meaning" to the enzyme.

At the other end of the complexity spectrum, we can imagine a thinker pondering the "meaning of meaning". This means that the attribution of meaning to a message includes a spectrum of such phenomena, starting with the process of attribution of meaning, which does not require intelligence. At the top of the spectrum, represented by the thinker's brain, the internal information environment is so rich that it enables comparisons of incoming information with many different aspects of pre-existing organized information (knowledge), thereby gaining meaning on many different levels. This multitude of "semantic" interactions leads to the creation of new structures of knowledge and insights.

Meaning is a state that determines the relationship between two categories of information: external information that the recipient's system has received from the outside, and information that the recipient's system has previously stored and that can interact with incoming information. If the external information interacts with the recipient, it is called a message, and the previously stored information is called the context, which Stonier [57] also calls the internal information environment. The interactions between these two forms of information determine the extent of meaning the message has for the recipient. More interactions create more connections between the new information and the various structural information that exist within the recipient's information environment. More such interactions mean that the new information will have more meaning for the recipient.

In the case of an enzyme-substrate interaction, a purely chemical interaction results in the formation of chemical bonds between two molecules.

In the case of the cleaner who found the puzzle piece, the visual information stimulus in the brain results in semantic connections between the mental representation of the puzzle piece and the information store in the brain. A puzzle piece not only creates a set of semantic connections, but the resulting semantic complex becomes an internally generated message that moves from one pattern (gestalt) to another.

The creation of enzyme-substrate associations and semantic associations is part of a general process called "metabolism", whether such metabolism is cellular or semantic.

Message and codes exist before meaning. Our world is filled with messages (sunlight, radio waves, books on library shelves ...) that exist independently of whether the receivers exist or not. Sunlight existed before plants, radio waves propagate regardless of receivers, and only once, there are tons of unread books on library shelves! This is the case until the radio broadcast listener or library user absorbs this information and interactions between the input information and his internal information environment are triggered to make the message meaningful regardless of its form.

The sound (vibration of air molecules) of a fallen tree cannot become meaningful without a recipient!

But what are the tasks of the sender? There are two types of senders: senders who send a message specifically for a specific target group of recipients and senders who send messages without an idea of recipients in their head or senders are completely different from the recipients for whom the message is intended. In the latter case, it is about emitters or transmitters of information and not senders.

The purpose of the sender is as true for humans as it is for ants and hormone glands! In all these cases, the sender sends a message to the receiver with the intention of influencing his behavior. In each of these cases, the sender tries to shape the message so that it has meaning for the intended recipient.

The significance and purposefulness of a message cannot be measured without taking into account the internal information environment of the recipient to whom the message is intended.

The meaning of the message and its relevance to the recipient depends on the sender's ability to shape the message in accordance with the internal information environment, which is also called the context (language skills, general and professional knowledge, needs, motives...) of the recipient.

Stonier [57] gives an example of the inscription PECTOPAH in Cyrillic (RESTORAN in Latin). The sender intended it for a recipient who knows Cyrillic and has a need for food or some other motive to enter it. If the recipient does not know Cyrillic and does not understand the meaning of the word, the inscription is meaningless as a message. If he knows Cyrillic and understands the meaning of the word, but is not hungry or has some other motive to enter it, the inscription as a message has meaning, but is not important, i.e. relevant to the recipient.

This also applies to the meaning, purpose and relevance of this article and to its author as the sender, since the meaning and relevance depend on the ability and knowledge of the author to write the article and consolidate the information contained in it in accordance with the knowledge and needs of (Slovenian and Indian) professionals and the wider interested public according to the selected content of the book.

The operation of cellular metabolism as an information processing system appears to be more sophisticated than information processing by a computer and confirms the giant strides of the biological sciences in unraveling the complexities of biological systems.

The composition of living matter is different from anything we have studied in physical laboratories. [61] This does not mean that biological systems are not subject to the laws of physics that apply to physical systems from the infinitesimal to the cosmological, but rather that these laws involve principles that are not yet known to us.

Today, consciousness is a mysterious phenomenon, as life was two centuries ago.

Until the study of consciousness from an evolutionary perspective, such theories were extremely anthropocentric and androcentric, i.e. aimed at adults. Such are the theory of D. Layzer [62], according to which consciousness is a more unpredictable metaphysical object, and the theory of D.J. Chalmers [63] [64]), according to which special categories of psycho-physical laws apply to consciousness.

S. Greenfield [65] [66], observed correlations between the neurological structures that form the image ("gestalt") and the thoughts, ideas and perceptions that make up our inner self. Finding such correlations is only the first step. According to Sloman [67], we can talk about 75 different types of conscious.

According to Stonier [57], consciousness, like intelligence and understanding of meaning, includes the evolutionary spectrum of conscious phenomena, and it is not productive to start studying the conscious with human consciousness, as it represents the most complex phenomenon at the top of this developmental spectrum.

The presence of semantic metabolism is not a sufficient condition for consciousness, but it is certainly one of the necessary concepts of consciousness, in addition to collective intelligence, synergy, information transduction, virtual reality and information as a fundamental element of the universe - infon (in addition to matter, mass and energy). Information, like energy, can exist in a special form and is interconvertible with energy!

Pattern recognition vs. logic

We live in an age where logic rules. The ultimate extension of this explanation is the computer and its logical reasoning machine. The efficiency of the computer demonstrates the practicality and superiority of logic as a problem-solving method over all other approaches. But this plausible, persuasive logic-oriented view may prove to be a major obstacle to the further development of sophisticated AI thinking machines, since the human mind excels precisely at pattern detection. [7]

Pattern recognition is based on associating certain events or actions with certain objects or circumstances or with each other. "Common sense" is based on our ability to perceive patterns (pattern recognition), which is an important component of what we call "wisdom". Pattern association is, of course, a much more primitive form of intelligence than logic. It is only an extension of conditioned reflexes. A reflex is the simplest form of behavior in which there is a quick, stereotyped and involuntary response to a stimulus. If in the dog's environment - as in Pavlov's laboratory - a bell is always rung before the appearance of food, then the dog perceives a pattern: the ringing of the bell is likely to be followed by food[10]. Fish in an aquarium can be similarly trained to respond to external stimuli. Humans have much more sophisticated brains than fish. However, our ability to be much more sophisticated at detecting subtle patterns than fish does not prevent us from realizing that this difference reflects only a spectrum of phenomena - not a qualitative difference. Logic creates an unsolvable problem: logic, in case of wrong assumptions, inevitably leads to wrong conclusions! This is true for both mathematical and verbal logical arguments. However, science, using observation and experimentation as a method, transcends the cognitive process of "assumptions - drawing conclusions from generalizations to individual facts or to other generalizations" and thus always checks and compares the conclusion with the objective reality that it "projected". In nature, they must organisms act and make decisions quickly and with incomplete information.The same is true for managers and most people who have to make important decisions, which leads to wrong assumptions. the latter only to false conclusions, and pattern matching - gut reactions - is a much more reliable guide than logic, especially when it involves shared prejudices based on past experiences of the collective intelligence of a given culture!

Global Information Infrastructure and Automatic Semantic Indexing

In his article Interspace: A Navigational Concept for Distributed Communities, Bruce R. Schatz [68] illustrated the evolution of the global information infrastructure in waves (Figure 3):

• First wave 1965–1985

ARPANET; it began to be developed at the US Defense Department; it supported access and packet data transfer between computers, then e-mail and exchange;

• Second wave 1985–2000

INTERNET; moving from packages to objects; the internet has enabled the transfer of objects between knowledge repositories; the concept of document browsing began with the development of the telesophy system prototype in 1984–1989 to use interconnected objects for transparent navigation across the global information network; in 1984, the development of a prototype of the World Wide Web began at the European Organization for Nuclear Research (European Organization for Nuclear Research); in 1994, Schatz and colleagues developed the first graphical browser for the World Wide Web, Mosaic, based on the telesophy paradigm at NCSA (National Center for Supercomputing Applications) of the University of Illinois; at the same time, the World Wide Web was developed at CERN; Mosaic and the World Wide Web brought information spaces;

• Third wave 2000–

INTERSPACE; represents a transition to a radical new paradigm of online information retrieval; interspace connects all knowledge spaces on the global network; with the navigation of concepts, it enables switching over the most diverse repositories of individual communities in a certain specialized subject area; in the period 1997-2000, Schatz and colleagues developed an interspace prototype with the support of the DARPA Information Management program; the implementation of interspace presupposes the exponential growth of information on the global network and the rapid development of the capacity of personal computers to act as supercomputers (supercomputing); Schatz predicted that after the integration of interspace into the global information infrastructure, navigation by concepts will be a common service on the global network.

[10] Ivan Petrovich Pavlov (1849-1936), Russian physiologist, 1904 Nobel Prize laureate in Physiology or Medicine

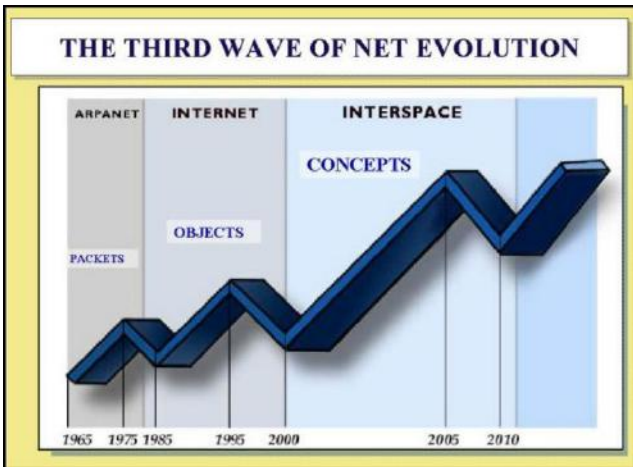


Fig.3: Net-evolution [68]

Interspace Levels:

• The level of unrelated repositories of individual communities in a certain specialized subject area (e.g. colorectal Neoplasms, Heredity Nonpolyposis (subject area - source) or Genes, Regulator (target subject area));

• Object level, i.e. documents in the form of full texts within the repository of an individual community;

• The level of conceptual spaces within a specialized subject area, e.g. a thesaurus for a given field.

The problem that needs to be solved when locating a relevant document in full-text form is how to bridge the border between different repositories of individual communities in a certain specialized subject area. Various browsers (eg Mosaic and WWW) have been developed to search for a document on the Internet. Searching through interspace, however, requires new technology. For online search across resources, the number of which is growing exponentially, Schatz and colleagues developed an interspace prototype in the CANIS (Community Architectures for Network Information Systems) laboratory at the University of Illinois in 1997-2000, and before that, as part of the Illinois Digital Library project (1994-1998) at NCSA (National Center for Supercomputing Applications) developed algorithms for automatic semantic indexing.

Interspace is radically changing the way we interact with knowledge.

A condition for the functioning of interspace is that each community in a certain specialized subject area identifies concepts within its repository, indexes these concepts on a generic level and in a way that is suitable for mapping generic concepts in the repositories of other communities. It is about the development of ontologies [69] [70]), which define important terms in a given field in an orderly manner. Ontologies are based on different languages, the development of which now depends on the reliability of their developers, which is problematic, since we are not infallible. Handwork is also very expensive. These facts have accelerated the development of automatic indexing techniques whenever possible.

Kolenc, Oštir and Šercar [71] at the 7th World Multiconference on Systemics, Cybernetics and Informatics (also) SCI 2003 in Orlando, Florida, USA, proposed the name "ontobroker" for experts who are involved in the development and use of ontologies in a given specialized subject area. Ontobroker (onto-gr. on, ontos bit, being, broker, English broker broker, broker, stock exchange agent) is a new professional profile, intermediary specialist between unstructured network resources and the user.

For true conceptual navigation, semantic indexing must include five robust technologies that can be adapted to many applications and purposes:

- presentation of documents,
- language analysis,
- statistical indexing,
- peer-to-peer networking and
- replacing the concept.

Some of these technologies are already widely implemented, while others are relatively underdeveloped.

Interspace will become a reality when all these technologies are in commercial use and become part of the information infrastructure.

As mentioned, the starting point of interspace is the structure of concept spaces. The search interspace prototype consists of:

- indexing services with protocols that support automatic semantic indexing of document collections of individual communities in a certain specialized subject area;
- an analysis environment that uses semantic indexes of common sets of concepts to navigate within a single collection and across different collections at the level of these common sets of concepts.

Automatically generated semantic indexes are equivalent to standard indexes in physical libraries. Semantic indexes represent abstract spaces for generic concepts and categories, which are common to concrete collections of units and objects, but are independent of them, as they are generic concepts and categories.

A term space contains words that appear together within documents. Words are units and documents and images are objects. By navigating through a specific conceptual space, we can find related terms, which are necessary for a more demanding search strategy for searching with another search word that appears together with the initial word in different contexts, with which we failed to find the desired document. In this interactive search, we also use manually developed semantic thesauri (e.g. MeSH or Inspec).

Category mapping (category map) includes objects that appear together within concepts, e.g. two documents that overlap in many of the same terms. By mapping categories, we can identify clusters of similar objects to browse and the location of some sub-collection to find the desired units.

For concept navigation supported by the interspace prototype, scalable semantics is used for indexing. Balance refers to the range of subject areas that can be semantically indexed, while semantics refers to the depth of meaning that can be achieved through semantic indexing. While traditional full-text search technology is broad and shallow, and in the case of expert systems deep and narrow, the semantic indexing used in the interspace prototype is balanced against the aforementioned extremes for shallow analysis of large collections and deep analysis of small collections.

The result of the analysis (parsing) is generic terms extracted from the objects, and the result of indexing is the correlation between these generic terms in a countless number of different sources after uniform statistical processing. For text documents, generic terms are noun phrases. With statistical indexes, we record the frequency of co-occurrence of words, that is, how often each phrase appears with every other phrase in the document within the collection.

Automatic analysis of all concepts and computer calculations of all relationships support so-called concept switching from cluster to cluster, and then from term to term. Cluster-to-cluster concept switches generate some class of equivalent related concepts in a given situation, and then map a given class of equivalent related concepts from one space to the most relevant classes of equivalent concepts in other spaces. Neural network technology will probably be used for complete conceptual switches in the future.

The interspace prototype enables navigation across different levels of space for documents, concepts and categories. Users can move from a folder of categories to the concept space, concepts, documents, and back again from concepts in a given document to higher levels of abstraction.

A supercomputer simulation of interspace was performed on the Illinois Digital Library Project's Engineering (1994–1998) and Medicine (1998) repositories. A Medspace semantic index of all records in the Medline database was created. [72]

Medicine is the largest scientific discipline. Using the NLM Medical Subject Heading classification, the collection was divided into approximately 10,000 individual community repositories in a given specialized subject area. Concept spaces were created for each community so that Medspace contained 400 million phrases within 40 million extracts.

The average user is expected to routinely perform semantic indexing on their own personal computer. Semantic indexing will evolve to the extent that it will expand beyond concepts and categories to perspectives concerning concepts within categories and to situations concerning categories within collections. The increasing capabilities of personal computers will allow calculations of many relationships. Information infrastructure should support navigation within the broadest context of universally accessible knowledge, and more abstract semantic levels should support a closer connection of meaning in our heads and objects in the real world.

In the foreseeable future, the current direction of development will turn towards the use of computer semantic processing of information based on statistical calculations of correlations between each word and all other words in full-text databases with the support of supercomputers and powerful personal computers.[11]. [68]

Connectome, connectomics, bioinformatics

In June 2005, the Ecole Polytechnique Fédérale de Lausanne (EPFL) and the computer corporation IBM (International Business Machines Corporation) signed an agreement to launch the Blue Brain Project (BBP). The agreement provided for the installation of the BlueGene supercomputer on the EPFL campus. IBM's Blue Gene supercomputer with a speed of 70.72 teraflops[12] was built for the needs of the US Department of Energy laboratory. In February 2006, the project was designed and the goals and methods defined. [73] Over the summer, a team of BBP scientists built the first model of a cortical column using a simplified neuron model.

One of the greatest challenges of neuroscience is to determine the "map" of synaptic connections between neurons. Named "connectome", this map is supposed to show the connection of synapses with a virtual

[11] I then exchanged two e-mails with colleague Schatz, but when I realized that he was not ready to discuss the merits in more depth, I stopped correspondence!

[12] A flop is a measure of the number of real number operations performed per second, and a teraflop is equal to a trillion such operations per second.

reconstruction of the microcircuit and the flow of information in the brain. [74]

The term "connectome" for a map of connections between neurons in the brain, for an intercortical "wiring (circuit?) diagram" was independently and simultaneously proposed in 2005 by Sporns and colleagues at Indiana University and Hagmann at Lausanne University Hospital. The term was coined after the sequencing of the human genetic code in the construction of the genome. The compilation and analysis of connectomic datasets has been called connectomics. [75] [76]

In order to understand the operation of an information transfer network, the type of network, its elements and connections must be known. The term connectome is essential to cognitive neuroscience and neuropsychology, as it shows how functional brain states arise from their structural bases and how disrupted structural substrates affect brain functions. Konektom supports a large number of dynamic state variables depending on current sensory inputs, sensory stimuli, global brain state, learning and development. [76]

The basis for systemic mapping of brain pathways is axon tracing. An axon (Gr. ἄξων - áxōn, lat. axis, axis) is an extension of a neuron, i.e. a fiber that transmits information in the form of electrical impulses between neurons, between them and muscles, glands and effectors in general.

The neuroinformatics database enables continuous updating of anatomical maps of connections, which are the key to understanding distributed and cooperative (distributed and cooperative) brain functions. An example of such a database is the online CoCoMac. [77] Kötter systematically collected data on the connectivity of primate brain areas from published reports of such experimental studies. Standardized interfaces open up additional possibilities for automated searching, for data visualization and for interoperability with other databases. Monitoring results point to the possibility of automatic integration with other neuroinformatics resources, which enable the selection and processing of connectivity data, for example, for computational modeling and interpretation of functional imaging studies.

Human Brain Projects

The Human Brain Project (HBP) EU 2012-2022

The Human Brain Project (HBP) was announced by Markram et al. in 2011. The HBP is a candidate project in the European Union's flagship FET (Future and Emerging Technologies) programme, funded by the Information and Communication Technologies (ICT) programme under the Seventh Framework Programme of the European Union for Research and Technological Development and Demonstration Activities 2007-2013. The project will develop a new integrated strategy for understanding the human brain and a new research platform that will integrate all the data and knowledge that can be obtained about the structure and function of the brain and use it to build unified models that can be validated by simulations running on supercomputers. The project will stimulate the development of supercomputing for the life sciences, generate new neuroscience data as a benchmark for modelling, develop radically new tools for informatics, modelling and simulation, and build virtual laboratories for collaborative basic and clinical studies, drug simulation and virtual prototyping. neuroprosthetic, neuromorphic and robotic devices. [78]

Understanding the human brain is one of the greatest scientific challenges of the 21st century. The EU Human Brain Project aims to answer the question of what it means to be human, discover new treatments for brain diseases and build revolutionary new ICT. The convergence point between ICT and biology was crucial for the launch of the HBP. [79]

The HBP pursued four objectives related to data, theory, ICT platform and applications:

1. Data: to generate and interpret strategically selected data that are essential for the construction of brain atlases, the construction of brain models and the acceleration of contributions from other groups.

2. Theory: to define the mathematical principles underlying the relationships between different levels of brain organization and their role in the brain's ability to acquire, represent and store information. Without a solid theoretical foundation, it is impossible to overcome the fragmentation of data in the field of neuroscience and research. Under this programme, the HBP is to establish a European Institute for Theoretical Neuroscience[13], which will also encourage the participation of scientists outside the project and act as an incubator for new approaches.

3. ICT platforms: to provide an integrated system of ICT platforms for neuroscientists, clinical researchers and technology developers to accelerate the pace of their research. The development of an integrated system of ICT platforms dedicated to neuroinformatics, brain simulations, medical informatics, high-performance computing, neuromorphic computing and neurorobotics is the foundation of new brain research.

[13] The European Institute for Theoretical Neuroscience (EITN) was established in March 2014 as part of the theoretical neuroscience activity of the Human Brain Project (HBP) and is managed by the Paris-Saclay Neuroscience Institute (Neuro-PSI), a unit of the CNRS (Centre national de la recherche scientifique).

4. Applications: develop first draft models and technology prototypes on ways to immediately use the platform in neuroscience, medicine (diagnosing and treating brain diseases) and computing.

The HBP was organised in three phases, lasting a total of ten years, 2012-2022.

The first two and a half years (initial "ramp-up" phase) – development and deployment of initial versions of ICT platforms and their filling with strategically selected data; at the end of this phase, use of the prepared platforms within and outside the project.

The next four and a half years ("operational phase") – generation of strategic data and development of new platform capabilities, while also establishing platforms for basic neuroscience research, for applications in medicine and for future computing technology.

The last three years ("sustainable phase") – continuation of previous activities, while also aiming for financial self-sustainability – ensuring capacities and knowledge for the needs of European science and industry.

The total costs of the HBP are estimated at approximately EUR 1,190 million, of which EUR 80 million for the "ramp-up" phase, EUR 673 million for the operational phase and EUR 437 million for the sustainable phase. The EU Commission is planning to fund the HBP with €643 million.

The HBP is a major ten-year interdisciplinary project involving partners from more than twenty countries and a significant budget. The project management and governance are strong and flexible, ensuring that the ICT platforms are a real community resource. The activities critical to the project mission are carried out by a consortium of partners (the HBP consortium), the composition of which evolves during the project. Research using the ICT platforms is organised in the form of research projects, selected through a competitive procedure open to the entire scientific community.

Audiatur et altera pars, "Listen to the other side", or "let the other side be heard as well"!

The European Human Brain Project (HBP) began with a scandal and a crisis! [80]

The essence of the problem is best expressed in the title of their article "Where is the brain in the Human Brain Project?" The €1 billion European science and technology project on the human brain needs to clarify its objectives and establish transparent governance.

The crisis culminated in an open letter from neuroscientists to the European Commission on 7 July 2014, signed by more than 750 scientists at the time, including former HBP participants, to refrain from participating in the planned call for "partnership projects". Frégnac and Laurent [80] were convinced that this would result in a decrease in the quality of the final project result and leave the planned databases empty.

The origin of the crisis is mainly in the order of priorities, with informatics and database construction in the foreground, and neuroscience and "the brain" in the background. The result will be wasted money and empty databases without scientific content, at least as far as scientific knowledge about the human brain is concerned.

Instead of generating knowledge about how the brain works, the HBP is turning into an expensive IT project to manage databases and hunt for new computer architectures. In recent months, the HBP executive board has revealed plans to drastically reduce its experimental and cognitive neuroscience arm, sparking outrage in the European neuroscience community.

The main source of the problems lies in the fact that the Blue Brain Project, a computer research program launched in 2005 by Markram, the charismatic leader of the entire project and a collaboration between the Swiss federal institute of technology in Lausanne (École Polytechnique Fédérale de Lausanne, EPFL) and IBM , is being favored over brain research. In addition, many scientists have also feared that the HBP will also benefit from European Commission funds for basic research, and that investment in a large "brain project" will proportionally reduce funding for other research areas.

To add to the irony of this episode, the impression of the European Union's extraordinary investment in brain research has encouraged the emergence of similar, well-funded neuroscience projects in the US (focusing on developing techniques) and China (focusing on brain disease). Last but not least, it is now unclear whether Europe has invested in brain science at all through the HBP. [80]

On 28 January 2013, the European Commission announced that the Human Brain Project (HBP) had been selected as one of two FET[14] 'Flagship' projects with a 10-year funding of €1 billion and the aim of simulating the human brain with supercomputers to better understand brain function and diagnose brain disorders.

On the other side of the Atlantic, US President Obama, in his 2013 State of the Union address, shocked the global neuroscience community by announcing a 10-year, $3

[14] FET Flagships are science-driven, large-scale, multidisciplinary research initiatives built around an ambitious unifying vision. They tackle grand S&T challenges requiring cooperation among a range of disciplines, communities and programmes, including both academia and industry.

billion project, the ‘Map of Brain Activity’, which aims to ‘take a picture of every spike of every neuron’. This was followed on 2 April 2013 by the announcement of the BRAIN (Brain Research through Advancing Innovative Neurotechnologies) initiative from the White House, which promises multi-agency support for the development of new technologies for studying the brain.

The mega brain projects announced by the US President and the European Commission in 2013 offer new incentives for the development of innovative neurotechnology, but the prospect of effective therapies for brain diseases remains uncertain. [81]

The BRAIN Initiative in the USA2014-2025

In 2013, US President Barack Obama launched the BRAIN (Brain Research through Advancing Innovative Neurotechnologies) initiative, which is just one of his many progressive initiatives[15].

Morgan and Lichtman (2013) [82] wrote: “Neuroscience is at its peak: major initiatives are underway in Europe and the United States. Annual neuroscience meetings with tens of thousands of participants are like small cities. The number of scientific papers published in neuroscience has more than doubled in the past two decades, surpassing those in fields such as biochemistry, molecular biology, and cell biology. Despite the number of important advances we have heard about, surely we should not think that we are on the verge of understanding how healthy brains work and how to fix them when we are not?”

Opinions on whether mapping the brain’s synaptic connectivity is a good idea are divided. Morgan and Lichtman show that such maps, despite their limitations, reveal essential features of neural circuits that would otherwise be inaccessible. The brain is a “tough nut to crack.” No other organ is associated with such a long list of incurable diseases. For many common diseases of the nervous system, not only is there no cure, but there is no clear idea of what is wrong. Few psychiatric illnesses, learning disorders, or even severe pain syndromes like migraine have pathognomonic signs (characteristics of a particular disease): there are no blood tests, radiographic and electrophysiological findings, or brain biopsies to make a diagnosis. This dilemma is different from that of other organs, where disease is almost always associated with pathological tissues and/or biochemical signs. A patient may come to us for help with abdominal pain, but the doctor discovers the cellular or molecular cause of the pain before treatment can be started. Why is this not true of the brain?

It is not surprising that those of us interested in a deeper understanding of the structure of the brain see a problem in the structure. The nervous system is a physical tissue unlike any other organ. The brain contains many more types of cells. The retina alone has more than 50 different types of cells, while the liver has about five. Because of their complex geometry, neurons are connected (via synapses) to many more cellular partners than cells in other organs. Neuronal connections form circuits that have no resemblance to other tissues. The fine structure of neuronal circuits is quite diverse, and differs from the pronounced structural redundancy in other organs, where the same multicellular motif (for example, the renal nephron, the basic functional and morphological unit of the kidney) is repeated many times. **Perhaps the most intriguing difference between neural tissue and other organs is that the cellular structure of neural tissue is both a genetically inherited product and a product of experience. The structure of each of our nervous systems is thus personalized.**

The unique structural features of the nervous system are probably why it is more difficult to understand than other organs. However, a more complete connectivity of the neural circuitry (i.e., the connectome) would make this problem even more difficult to solve. With such an understanding, diseases that manifest as abnormalities in behavior, thought, and learning, or as pain, may become as clearly linked to the underlying pathological structure as diseases of other organs. Knowing the faults is a good first step in finding a solution. For proponents of connectomics, the cost of providing such research is justified. But not everyone agrees. Connectomics may require an industrial effort similar to the initiatives that made genomics possible. Given the current tight budget constraints, connectomics may be ill-advised. Some argue that connectomics is a waste of money, even if it were free, and argue that anatomical maps do not essentially reveal how the brain works. They cite a number of arguments against connectomics in support of this view.

However, despite the many arguments against connectomics analysis, it should be pursued for three reasons. First, the contingent patterns of synaptic connectivity that emerge during development and experience are inaccessible to techniques that sample only a few cells at a time. Second, neuroscientists cannot claim to understand the brain as long as the network level of

[15] The 2005 Ethics Policy Reform Initiative, the 2009 Healthcare Reform Initiative, as there were 46-50 million people without health insurance in the US, the 2011 US Employment Initiative, the 2012 Food Security Initiative, the 2013 Gay Openness Initiative, the 2016 Gun Control Initiative, which the Republican leadership described as an initiative to "undermine freedom", the 2016 Criminal Justice Reform Initiative, the 2016 Cancer Fight Initiative, ...

brain organization is unsophisticated; without this detailed information, neural physiology is a black box with systems physiology. Third, such research is likely to uncover unexpected properties by shining light (or electrons) on this most mysterious tissue! [82]

The BRAIN initiative aims to accelerate the development and application of innovative new theories, methodologies, and neurotechnologies in brain research.

President Barack Obama, announcing the BRAIN initiative, said that this is an opportunity to improve the lives of not just millions, but billions of people on the planet through BRAIN research. This requires serious and sustained efforts, including from the state, to embrace the spirit of discovery that has made America America!

The President's call was quickly followed by a commitment to the initiative by dozens of leading technology companies, academic institutions, scientists, and other neuroscience collaborators. That same year, they developed a 12-year research strategy for the National Institutes of Health [83]) to achieve the goals of the initiative[16].

The BRAIN Initiative is to neuroscience what the Human Genome Project was to genomics!

The BRAIN Initiative offers the potential to create a treasure trove of information about the nearly 100 billion neurons in the human brain. A greater understanding of neuronal dynamics and function is helping researchers unlock the mysteries of brain disorders such as Alzheimer's and Parkinson's disease, depression, and traumatic brain injury (TBI). It is accelerating the development and use of new technologies that allow researchers to produce dynamic images of the brain, showing how brain cells and complex neural circuits influence the speed of thought. New technologies are opening the door to research on how the brain acquires, records, processes, uses, and stores vast amounts of information, and are revealing the complex connections between brain function and behavior.

The NIH has established a working group to design an Advisory Committee to the NIH Director (ACD) initiative. Their BRAIN 2025 report, published in June 2014, summarized the scientific goals of the BRAIN initiative and developed a multi-year scientific plan to achieve the goals, including timelines, milestones, and cost estimates. The scientific vision in BRAIN 2025 requires the ideas of the best scientists and engineers in various disciplines and sectors. Therefore, government agencies, including the NIH, the U.S. Defense Advanced Research Projects Agency (DARPA), the National Science Foundation (NSF), the U.S. Food and Drug Administration (FDA), and the U.S. Intelligence Advanced Research Projects Agency (IARPA), which primarily fund numerous research programs to improve the cognitive and physical capabilities of American soldiers and spies, are working with private partners who are also committed to investing in the successful BRAIN initiative. [84] [85]

The NIH Director's Advisory Committee Working Group answers all the questions in the Star of David: what, why, who, when and where, how and how much!

The fundamental problems in neuroscience are perception, emotion and motivation, cognition, learning and memory, and action.

The focus is on mapping brain circuitry by measuring the fluctuating patterns of electrical and chemical activity that flow through these circuits, and understanding how their interactions create our unique cognitive and behavioral abilities.

Available imaging technologies, microscopy and optics, genetics, and computing are expanding the scope of what is possible, but to harness the potential of a circuit, it must first be identified.

The priority research goals of the initiative are therefore:

1. Identify and provide experimental access to different brain cells and determine their role in health and disease.

2. Create circuit diagrams of synapses and the brain as a whole.

3. Build a dynamic picture of brain function by developing and applying improved methods for monitoring neural activity.

4. Use precision tools to establish causal relationships between brain activity and behavior.

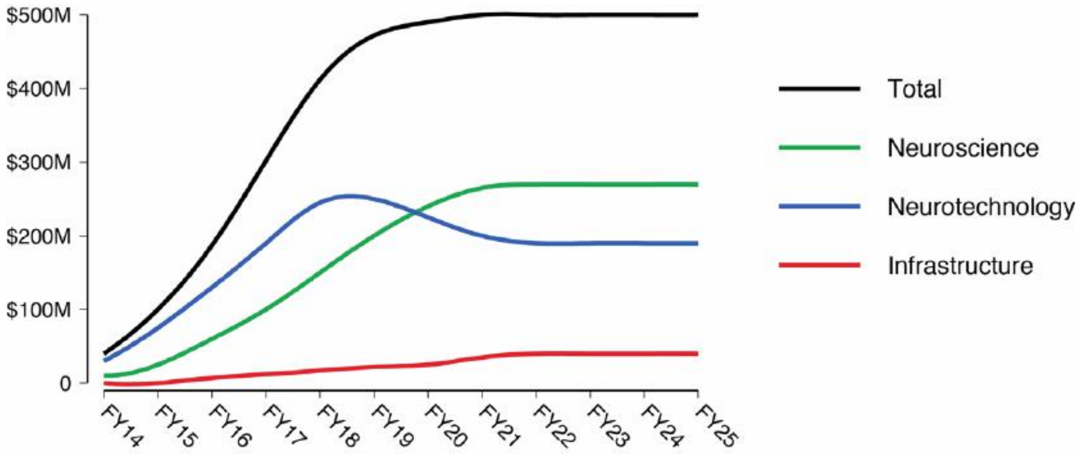
5. Use new theoretical assumptions and data analysis tools to develop conceptual foundations for understanding the biological basis of mental processes.

6. Develop innovative technologies for understanding the human brain and treating disorders.

7. Integrate new technological and conceptual approaches generated in goals 1-6 to determine how dynamic patterns

[16] The initial BRAIN partnership included the federal agencies National Institutes of Health (NIH), National Science Foundation (NSF), Intelligence Advanced Research Projects Activity (IARPA), Defense Advanced Research Projects Activity (DARPA), Food and Drug Administration (FDA), foundations and private research entities Howard Hughes Medical Institute, Allen Institute for Brain Science, The Kavli Foundation, The Simons Foundation, University of Pittsburgh, University of California, Berkeley, Carl Zeiss Microscopy, The Carnegie Mellon University, and private companies General Electric, GlaxoSmithKline, Inscopix, and US Photonics Industry [83]

of neural activity in health and disease are transformed into cognition, emotion, perception, and action.



Budget for projects for fiscal years (FY) 2014-2025

The budget for 2014 was 40, for 2015 100 million US dollars ($).

In the five-year period 2016-2020, the emphasis is on technology development, in the next five years 2021-2025 on scientific discoveries.

Steep annual increase to $ 400 million by fiscal year 2018; plateau at $ 500 million from 2021 onwards. Total investment amounts to $ 4.5 billion.

Among the latest research using transconnectomics and connectID in the field of connectomics, the results of the experiment by Klingler et al., published on July 27, 2018 as a preprint in bioRXIV the preprint server for biology [86] [17], stand out for their theoretical, methodological, and technological innovation.

A revolutionary brain mapping method called Mapseq (Multiplex Analysis of Projections by Sequencing) was developed in 2015 by Anthony M. Zador of Cold Spring Harbor Laboratory (CSHL) and his colleagues involved in the BRAIN initiative. [87]

Brain/MINDS: Japan's National Brain Project 2014-2024

In 2013, following a remarkable convergence of scientific advocacy and political vision, two large-scale national research projects, the US BRAIN Initiative and the EU Human Brain Project (HBP), were launched to advance the scientific understanding of the brain. In Japan, this movement mobilized the neuroscience community to consider how to contribute to global issues in neuroscience. Policy discussions identified brain research in non-human primates as a necessary step to bridge the fundamental progress from current animal models such as the mouse to a detailed understanding of the human brain. For disease studies in particular, scientific insights from primate brains were seen as an indispensable component of translational research towards evidence-based diagnosis and treatment of human psychiatric, neurological, and neurodegenerative disorders. The conclusion of this discussion called for Japan to adopt a fundamentally different approach compared to the larger and broader scope of the US and EU brain projects, by focusing on advancing the development of the common marmoset (Callithrix jacchus), a small primate, as a model for research and discovery of knowledge-based strategies for eradicating major brain disorders. [88] Based on these considerations, the Brain/MINDS (Brain Mapping by Integrated Neurotechnologies for Disease Studies) initiative was launched in June 2014 with the support of the Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT) and the newly established Japan Agency for Medical Research and Development (AMED). The 10-year roadmap for Brain/MINDS calls for the completion of a multi-scale marmoset brain atlas and integrated data platforms to support functional studies, the creation of genetically modified (GM) marmosets for experimental and preclinical studies, and the establishment of a clinical data center using translational biomarkers for the diagnosis and treatment of human brain diseases.

Brain/MINDS is a national brain project launched by Japan in 2014. With the goal of developing the common marmoset as a model animal for neuroscience, the project aims to build a multi-scale map of the marmoset brain, develop new technologies for experimentalists, create

[17] The team members divided the work and authorship as follows: project idea and experiment design E. K. and D. J.; experiment implementation E. K.; bioinformatics analysis E. K. and J. P.; provision of Sindbis virus and expert participation in MAPseq. J. M. K. and A. M. Z.; manuscript writing E. K. and D. J.; revision and editing of the manuscript A. M. Z. and A. D. This is a new, precise model method of transparent "sharing" of copyrights between the authors of a scientific article.

transgenic lines to model brain diseases, and integrate translational findings from the clinical biomarker landscape. Brain/MINDS will collaborate with global brain projects to share technologies and resources.

The GM marmosets are produced using viral vector and genome editing techniques. The SRBPS (Shri Rama Bharti Public School) project is developing rapid methods for breeding genetically modified and cloned marmosets. The Brain/MINDS project is developing multimodal imaging along with analytical and bioinformatics tools.

The key goal is to map the brain of a small monkey, the common marmoset, as a major step towards better understanding the human brain and developing knowledge-based strategies for the diagnosis and treatment of human psychiatric and neurological disorders.

Total funding for the Brain/MINDS project: 40 billion yen ($365,163,410, $1 = 109.54 yen). After inviting the public to submit specific proposals in 2013 and 2014, Brain/MINDS selected 65 laboratories in a total of 47 institutions for funding.

Brain/MINDS includes four main research groups (http://www.brainminds.jp/); (A) Structural and functional mapping of the marmoset brain, (B) Development of innovative neurotechnologies for brain mapping, (C) Human brain mapping and clinical research, and (D) Advanced technology and application development.

China Brain Project “Brain Science and Brain-Inspired Intelligence”, 2016-2030

The past few years have witnessed a global awareness of the importance of brain research, as exemplified by the large brain projects launched in Europe, the US and Japan. Understanding the neural basis of human cognition, which is a universal goal of neuroscience, should form the central pillar of the China Brain Project. In addition, China should devote its resources and research capabilities to addressing immediate societal needs. The growing societal burden of major brain disorders requires the development of new preventive, diagnostic and therapeutic approaches. In the new era of big data, brain-inspired computational methods and systems are essential to achieve stronger artificial intelligence (AI) and to exploit the ever-increasing amount of information. These considerations led to the “one body, two wings” scheme of the China Brain Project[18], in which basic research on the mechanisms of neural circuits underlying cognition provides inputs and receives feedback from the two applied wings of brain disease diagnosis/intervention and brain-inspired intelligence technology.

The China Brain Project “Brain Science and Brain-Inspired Intelligence” is designed as a 15-year plan (2016–2030), with the first five years coinciding with China’s 13th Five-Year Plan for National Social and Economic Development. As a relatively new research discipline in China, neuroscience has a small community and needs greater government support to strengthen research capabilities in almost all areas. On the other hand, given the current limited capacity, the project also needs to focus on selected areas, especially those where Chinese scientists have some advantages and can make significant contributions. The key question at present is how the project will be managed in line with the new reform of the S&T management systems, which is among the main priorities of the current government. [81]

Brain Initiative in the Republic of Korea 2016-2026

Pann-Ghill Suh, D.V.M. (Doctor of Veterinary Medicine) and PhD, the third president of the Korea Brain Research Institute (KBRI), said: “ The 21st century is considered the "Age of the Brain". [89]

KBRI is a government-funded research institute that has established an infrastructure for innovative brain studies and laid the foundation for research advancement since its establishment in 2011.

Brain research is emerging as a priority area in preparing for neurological disorders such as emotional, cognitive, and degenerative diseases resulting from rapidly evolving changes in the social environment. Meanwhile, we have entered an era in which we are striving for multidisciplinary research and collaboration among industries, academia, research institutes, and hospitals for innovative scientific discoveries.

In order to contribute to the well-being of humanity through brain research, we will build domestic and international networks with the goal of becoming "the world's leading brain research institute". In addition, we will make concerted efforts to develop advanced neuroscience technology by utilizing the efficient cycle in translational/reverse translational research as a strategy to secure a competitive advantage in the future.

The study of the mind and brain is the final frontier in science. By accelerating brain research, we hope to predict a comprehensive understanding of human behavior, pave the way for treatments that can prevent and cure brain diseases, and develop innovative approaches and strategies to cope with a rapidly aging society. Since 2013, many countries have launched large-scale long-term research

[18] "One body (understand the neural basis of cognitive functions; develop technological platforms for brain research), two wings (develop brain-machine intelligence technologies, develop effective approaches in early diagnosis/intervention of brain disorders. Core building and application development."

projects with the aim of revolutionizing our understanding of the human brain and uncovering the secrets of neurological disorders. In line with this global trend, the Korean government has developed a bold and ambitious plan to advance brain science and foster interaction between science and industry under its "creative economy" administrative agenda.

The Ministry of Science, ICT and Future Planning (MSIP) has formed an advisory board working group consisting of experts from academia, research institutes, and businesses to develop a 10-year plan for a revolution in brain science. With their dedication, in-depth research on science policies and trends in neuroscience has been conducted, and the Korean government announced the "Korea Brain Initiative" on May 30, 2016. The grand plan includes the development of neurotechnology and the strengthening of the neuroscience ecosystem with a vision to advance brain science by strengthening local, national, and global networks.

The Korea Brain Initiative embraces the role of brain science in driving the Fourth Industrial Revolution and aims to understand the principles of high-functioning brains, create a new dynamic picture of healthy and diseased brains, and develop personalized treatments for mental and neurological disorders through extrapolation, the concept of precision medicine, and fostering interaction between scientific institutes, academia, and industry.

In pursuing the goals of developing innovative neurotechnology and advancing the brain research ecosystem, a two-pronged strategy is employed, where the ecosystem works to bridge the gap between basic and applied research.

Strategic R&D includes:

- brain mapping at micro, meso and macro levels;
- multidisciplinary projects to develop technologies that integrate the physical, digital and biological worlds and play an important role in promoting the neuroindustry;
- R&D related to artificial intelligence; brain science is considered key to the development of next-generation computing technology; by promoting the connected R&D between natural intelligence (NI) and artificial intelligence (AI), advanced algorithms and AI modeling are expected to be developed, which will be a breakthrough for the fourth industrial revolution;
- personalized medicine for the prevention, diagnosis and treatment of brain disorders.

Strengthening the neuroscience ecosystem includes:

- promoting multidisciplinary research by training brain researchers in multiple disciplines;
- building a pipeline to facilitate the exchange of resources, accessible databases for sharing and storing data, and creating a central facility to provide research equipment;
- improving local, national and global networks to address challenging brain science questions;
- preparing for the future industrialization of cutting-edge neuroscience and establishing neuroindustrial clusters in the future.

Brain Research through Advanced Integrated Neuroanatomy (BRAIN) in India

In 2022, the Sudha Gopalakrishnan Brain Center, SGBC IIT Madras was established at the Indian Institute of Technology Madras (IIT Madras) to lead a global project to image the human brain at the cellular level and provide human brain datasets, scientific outputs and technological tools. [90]

SGBC IIT Madras is a multidisciplinary research and development center focused on brain research. The center brings together various disciplines from medicine, neuroscience, engineering, where brain research is conducted through advanced integrated neuroanatomy at the interface between neuroscience and engineering.

SGBC has developed a high-performance computational and experimental pipeline to study cellular architecture, connectivity and molecular architecture in the human brain using multi-resolution, multi-modal imaging, from cellular resolution histology to structural MRI. This effort is supported by the Office of the Chief Scientific Advisor, Government of India along with contributions from Mr. Kris Gopalakrishnan, Co-Founder, Infosys and distinguished alumni of IITM.

The Integrated Histology-Imaging Computational Pipeline at IITM generates petabytes of imaging data from post-mortem brains, neurotypicals and disease states. The centre leverages expertise across IITM, national and international collaborations for results that would have a significant impact on medicine, science and engineering.

Microbiome aka second brain

A revolutionary new science called psychobiotics is emerging, revealing the close connection between the brain and psyche and the microbiome, that is, the four-kilogram population of microbes that live in the human gut.

The microbiome is the collective name for the microorganisms that inhabit our skin, mucous membranes and bodily fluids. The intestinal microbiome has received the most attention.

Microbes maintain health, take care of the immune system and enable survival.

Around 10^{14} (one hundred thousand billion) bacteria, viruses, fungi, protozoa and archaea (intestinal flora) live in our gut, which are key to normal gut function. According to recent research, they are involved in almost all human diseases, from cardiovascular to mental. More than 2000 species of bacteria have been identified in the human gastrointestinal tract, and around 500 live in the average gut, with the most common 30 species representing almost 99% of all intestinal bacteria.

The gut microbiome (microbes in the gut) is as unique as a fingerprint, but the important difference is that we can change our microbiome!

Mental characteristics are not only passed down from generation to generation through heredity, but also through the gut microbiome!

The connection through which the brain and the microbiome communicate is the vagus nerve.

In 2017, Sc. C. Anderson (science journalist), J. F. Cryan (biochemist, pharmacologist, and behavioral neurogeneticist), and T. Dinan (psychiatrist) published a book on the biological foundations of the connection between lifestyle, diet, and environment and the gut microbiome, and the latter with the brain and psyche, both with mental health and mental illness, entitled The Psychobiotic Revolution: Mood, Food, and the New Science of the Gut-Brain Connection. There have been no significant advances in this field in the last thirty years and it is high time that a psychobiotic revolution begins! [91].

The microbiome is in constant communication with the intestinal tissue, the immune system and the brain. Some speak of the microbiome as an “organ”. The microbiome is something much bigger.

Cryan says: “The bacteria were there first, we came much later!” First there were bacteria, then there were humans, and it was not the microbes that settled in the human body, but rather humans who settled in their world. [92]

Microbes “communicate” directly with the mucous membrane of the inner wall of the intestine, then with the epithelial cells. If the intestinal wall is leaky, the bacteria cannot penetrate the tissue and activate the enteric nerves that surround the intestine like a sock, i.e. the second brain, which sends signals to the central nervous system. In this way, communication between microbes and the brain takes place. Mothers send signals for mental development through the microbiome. The immunological and mental stress response is more pronounced in those who were born by caesarean section, which prevents the colonization of microbes from the mother's vagina, which are indispensable for normal brain development.

The mother also feeds bacteria in the baby's gut with milk, which break down some sugars that the baby does not have in the gut and cannot break down on its own, for example into sialic acid, which is very important for brain development, intelligence quotient and cognitive abilities.

Microbes regulate the formation of new neurons and the branching of nerve cells, in short, changes in the microbiome have a strong impact on the growth, development and aging of the brain, on the taste of food, on the food we like to eat.

Social behavior affects microbes and conversely, microbes change social behavior

Communication signals between the gut and the brain are transmitted via the vagus nerve.

The vagus travels throughout the body and connects the brain with the stomach and digestive tract, intestines, kidneys and liver, lungs and heart, and with other nerves for speech, vision and face, it informs the brain about what is happening in our body. It is part of the autonomic nervous system, which acts sympathetically, and when we are in a stressful situation, it reduces the function of all the main organs - the immune, endocrine, digestive and reproductive systems, and parasympathetically, it affects the normal functioning of the glands, digestive tract, heart, kidneys, liver, promotes positive interactions with the environment and with other people, strengthens the feeling of security, acceptance, comfort, well-being, self-confidence and self-esteem, and is thus also responsible for our growth and development.

Vagus tone is the ability of the organism to "switch" the sympathetic system to the parasympathetic system. High vagal tone influences the rapid transition to a state of homeostasis after a stressful event, while low vagal tone has the opposite effect and a longer duration of the organism's stress response. Activation of the parasympathetic nervous system is strengthened by all techniques that increase vagal tone, such as massage, yoga, singing, empathy, socializing with people with whom we feel good, and the like.

First, they studied stress and developed a model for stress in early childhood. Chronic inflammatory bowel disease is an example of a disorder between the gut and the brain. A disorder in early childhood changes the microbiome for life. Stress affects the microbiome, and the latter affects the stress response. Today, every major meeting of neuroscientists has a roundtable discussion on the microbiome!

Only 20 years ago was the technology developed to study everyday, non-pathological communication. Today, the science of psychobiotics (diet, environmental influences, psychopharmacological agents) has also developed, with which we intervene in the microbiome with the aim of improving mental health. Part of the research focuses on autism and other social behavior disorders, anxiety, some characteristics of schizophrenia, shyness, introversion-extroversion. All of these phenomena can be influenced by communication between the brain and microbes. In the last 60, 70 years, the lifestyle in the West has changed radically, in such a way that it has an adverse effect on the microbiome. The use of antibiotics, industrially prepared foods and processed foods, and stress have increased significantly. All of this has affected the lack of bacteria that still lived in the intestines of our ancestors. A connection has also been discovered between chronic inflammatory bowel diseases, multiple sclerosis, depression, and the loss of certain microbes.

Psychobiotics aims to uncover the biological foundations of the microbiome's connection to health as well as various mental and other disorders.

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