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Development of Neural Networks in the Brain, and Their Possible Evolution

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Abstract

First, modern neurobiology is introduced. Next, we discuss the nonlinear whole biology and Lorenz mode1 of brain, which can vividly describe the general complementary of left and right brain functions. Third, we research development of neural networks in the brain, in this process the death of some neurons and cells will lead to the loss of certain functions. Such we may compare the differences between children and adults, and can identify these neurons and corresponding functions. Fourth, blind vision and brain plasticity are discussed. Cattaneo, et al., study blind vision that is a great work. Fifth, we search transformations among vision and other sensations, and possible tests. Sixth, we research neural network and quantum neuroscience in interdisciplinary studies. Neurobiology, as a frontier of scientific development, not only has many problems to be solved, but also can greatly improve the conditions for human survival.

Keywords: Brain, Evolution, Interdisciplinary studies, Neural network, Neurobiology, Quantum.

1. Introduction

Houghton pointed out: "Spike trains are unreliable" [1]. The nervous system is an unstable and uncertain system. Many data prove that the occurrence of extremely irregular pulse sequences in the cerebral cortex is impossible to repeat the obtained by the same experiment [2-7]. This illustrates the uncertainty of the neural pulse sequences. Gerald M. Edelman, winner of the 1972 Nobel Prize in Biomedical Science, pointed out, we have repeatedly stressed that one of the most prominent characteristics of each brain is its individuality and variability. This variability exists at all levels of the brain. This is a great challenge to any theory that tries to explain the overall function of the brain [8]. It is so different that every brain is unique, and the brain is not a computer. Some people pursue accurate neural coding, but can not actually find [8,9]. This uncertainty is accepted by most biologists.

At the same time, it leads to the sensitivity of initial value [7], degeneracy, and the existence of "free will" [10], the sudden emergence of inspiration, the ionic mechanism of inhibition [11] and so on. Small quantum effects affect macroscopic systems which must be unstable.

Many studies [2-7] have shown that extremely irregular pulse sequences in the cerebral cortex cannot be repeated with the same experiment. The small quantum effect affects the macroscopic motion of system, which shows that the uncertainty of neural pulse sequence. In this paper, based on the modern neurobiology, we research development in the brain and possible evolution.

2. Modern Neurobiology

Neurobiology is an important frontier of modern scientific development, which involves consciousness [12], evolution [13], mind [14,15], etc.

The brain has about 10^{14} synapses and 10^{11} neurons, which correspond to the number of galaxies in the universe and the number of stars in the Milky Way. and 10^{14} synapses,

In the neurobiology Hodgkin-Huxley equation is [16]:

$$I = C\frac{dV}{dt} + g_K(V - V_K) - g_{Na}m^3h(V - V_{Na}) - g_L(V - V_L)\,. \quad (1)$$

From this spatial extension system that identifies excitable components can support invariable waves, and allow powerful long-distance signaling. This is also the soliton.

FitzHugh-Nagumo dynamical equations of a single neuron are:

$$c\frac{dV(t)}{dt} = V(t) - V^3(t) - y(t)\,, \qquad (2)$$

$$\frac{dy(t)}{dt} = \gamma V(t) - y(t) + b + \sqrt{2D}\xi(t)\,. \quad (3)$$

Here b and c are constants, and $\xi(t)$ represents Gauss white noise. Eq.(2) as a nonlinear equation may derive chaos. We applied the qualitative analysis theory of the nonlinear equations, the characteristic matrix of Eqs.(2) and (3) is:

$$\begin{pmatrix} 1-3V^2 & -1 \\ \gamma & -1 \end{pmatrix}. \quad (4)$$

The solutions of $3V^2-1+\gamma=0$ are $(\pm\sqrt{1/3},0)$ and (0,1), and the results of the qualitative analysis are independent of b, c and a random term $\xi(t)$. This shown the scaling invariance and self-similarity, such it has a fractal character [17].

Hindmarsh-Rose model is:

$$\frac{dx}{dt}=y-ax^3+bx^2-z+I, \quad (5)$$

$$\frac{dy}{dt}=c-dx^2-y, \quad (6)$$

$$\frac{dz}{dt}=r[s(x-x_0)-z]. \quad (7)$$

From Eqs.(5-7), we obtain:

$$\frac{d(x+y-z/r)}{dt}=c-ax^3+(b-d)x^2-s(x-x_0)+I. \quad (8)$$

This (8) is only related to the x.

Others are Morris-Lecar model, Chay model, Rulkov model and Izhikevich model.

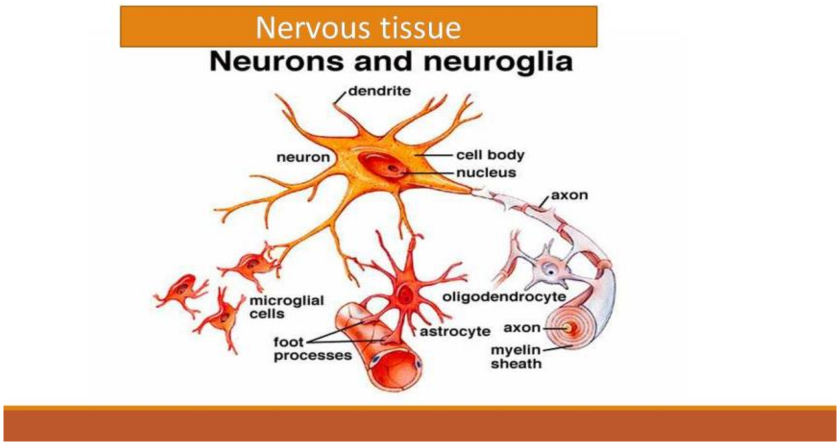

Figure 1. Structure of neuron, and neuroglia.

Figure 1 shows structure of neuron.

3. The Nonlinear Whole Biology and Lorenz Mode1 of Brain

Based on the inseparability and correlativity of the biological systems, we proposed the nonlinear whole biology and four basic hypotheses [18]. It may unify reductionism and holism, structuralism and functionalism, and is consistent with the systems biology. Further, the loop quantum theory is applied to biology, and proposed the model of protein folding and lungs, and obtain four approximate conclusions [18].

In biology there are widely various chaos, fractal [17] and soliton, etc. Based on the basic equations of synergetics, we derived quantitatively the Lorenz equations and Lorenz mode1 of brain, whose two wings correspond to two hemispheres of brain, and two hemispheres jump about, which describes thinking (Fig.2). It shows that life lies in cooperation in chaos [19]. This fits the complementary on left and right hemisphere of brain on language abilities studied by Broca-Jackson at 19th century [20]. Further this can vividly describe the general complementary of left and right brain functions.

Figure 2. X-Z view of Lorenz model.

Wilson-Cowan coupled nonlinear differential equations describe interactions of much interconnected neurons [21]. The equations are derived for the dynamics of spatially localized populations containing both excitatory and inhibitory model neurons.

4. Development of Neural Networks in Brain

Brain has the characteristics of specialized area manage corresponding functions, and has also the function-regional integration. Both all exist.

Now based on the rapid development of noninvasive advanced brain imaging technology and human brain connectivity computing methods, scientists have been able to explore the structural and functional connectivity patterns of the living human brain. Watts and Strogatz searched collective dynamics of ‘small-world’ networks [22]. It is confirmed that the human brain undergoes rapid growth in both structure and function from infancy through early childhood, and this significantly influences cognitive and behavioral development in later life. A newly emerging research framework, developmental connectomics, provides unprecedented opportunities for exploring the developing brain through non-invasive mapping of structural and functional connectivity patterns. Kelly, et al., discussed characterizing variation in the functional connectome [23]. Cao, et al., researched toward developmental connectomics of the human brain [24], and reviewed recent neuroimaging and neurophysiological studies investigating connectome development from 20 postmenstrual weeks to 5 years of age. Specifically, they highlighted five fundamental principles of brain network development during the critical first years of life, emphasizing strengthened segregation/integration balance, a remarkable hierarchical order from primary to higher-order regions, unparalleled structural and functional maturations, substantial individual variability, and high vulnerability to risk factors and developmental disorders [25].

At recent, European Union and United States have launched the Developing Human Connectome Project and the Baby Connectome Project. Both reflect the international focus on early childhood brain development research. So far, many questions still warrant further study. Hypothetic models of the brain connectome are development from infancy to early childhood (Fig.3).

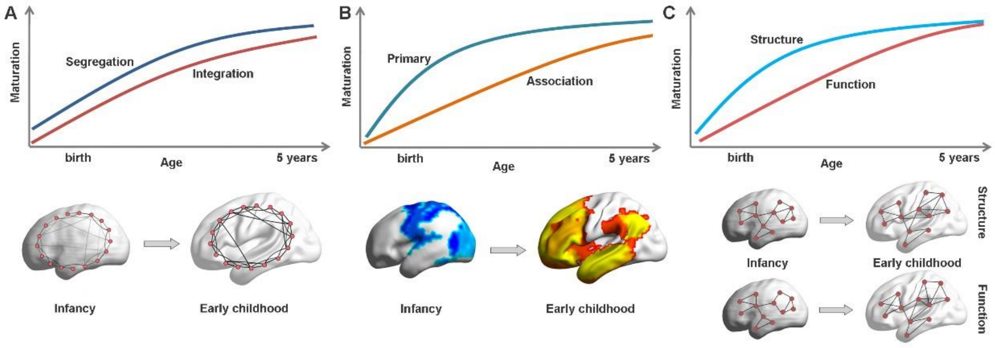

Figure 3. Hypothetic models of the brain connectome development from infancy to early childhood.

Cao, et al., discussed early development of functional network segregation revealed by connectomic analysis of the preterm human brain [26]. Ouyang, et al., searched short-range connections in the developmental connectome during typical and atypical brain maturation [27]. Zhao, et al., investigated graph theoretical modeling of baby brain networks [28]. Sa de Almeida, et al., studied preterm birth leads to impaired rich-club organization and fronto-paralimbic/limbic structural connectivity in newborns [29]. Li, et al., researched development of segregation and integration of functional connectomes during the first 1,000 days [30].

Further, Xie, et al., used mindfulness-based intervention to promote executive function in young children: a multivariable and multiscale sample entropy study [31]. Argyropoulou, et al., discussed functional connectivity of the pediatric brain [32].

Brain development explains the processes and function of synaptic blooming and synaptic pruning, and the concept of neural plasticity and its implications for the lifespan, and identifies three major brain developments in adolescence, and describes abnormal memory loss due to Alzheimer’s disease, delirium, and dementia [33]. Luppi, et al., studied a synergistic core for human brain evolution and cognition [34]. Squire, et al., discussed synapse elimination the 20th Chapter in Cellular and Molecular Neuroscience [35].

We are born with most of the brain cells that we will ever have; that is, about 85 billion neurons whose function is to store and transmit information.

Huttenlocher and Dabholkar compared the formation of synaptic contacts in human cerebral cortex in two cortical regions: auditory cortex (Heschl's gyrus) and prefrontal cortex (middle frontal gyrus). Synapse formation in both cortical regions begins in the fetus, before conceptual age 27 weeks. Synaptic density increases more rapidly in auditory cortex, where the maximum is reached near postnatal age 3 months. Maximum synaptic density in middle frontal gyrus is not reached until after age 15 months. Synaptogenesis occurs concurrently with dendritic and axonal growth and with myelination of the subcortical white matter. A phase of net synapse elimination occurs late in childhood, earlier in auditory cortex, where it has ended by age 12 years, than in prefrontal cortex, where it extends to midadolescence. Synaptogenesis and synapse elimination in humans appear to be heterochronous in different cortical regions. In other respects, including overproduction of synaptic contacts in infancy, persistence of high levels of synaptic density to late childhood or adolescence, the absolute values of maximum and adult synaptic density, and layer specific differences [36]. This is completely consistent with the time of the disappearance of specific function in children.

Zecevic and Rakic discussed synaptogenesis in monkey somatosensory cortex [37]. Bourgeois, et al., discussed synaptogenesis in the prefrontal cortex of rhesus monkeys [38]. Glantz, et al., discussed synaptophysin and postsynaptic density protein 95 in the human prefrontal cortex from mid-gestation into early adulthood [39]. Chance, et al., discussed auditory cortex asymmetry, altered minicolumn spacing and absence of ageing effects in schizophrenia [40].

While most of the brain's neurons are present at birth, they are not fully mature. During the next several years dendrites, or branching extensions that collect information from other neurons, will undergo a period of transient exuberance or temporary dramatic growth (exuberant because it is so rapid and transient because some of it is temporary). Because of this proliferation of dendrites, by age two a single neuron might have thousands of dendrites. Synaptogenesis, or the formation of connections between neurons, continues from the prenatal period forming thousands of new connections during infancy and toddlerhood. This period of rapid neural growth is referred to as synaptic blooming.

The blooming period of neural growth is then followed by a period of synaptic pruning, where neural connections are reduced thereby making those that are used much stronger. It is thought that pruning causes the brain to function more efficiently, allowing for mastery of more complex skills [41]. Experience will shape which of these connections are maintained and which of these are lost. Ultimately, about 40 percent of these connections will be lost. Blooming occurs during the first few years of life, and pruning continues through childhood and into adolescence in various areas of the brain.

Another major change occurring in the central nervous system is the development of myelin, which continues into adolescence but is most dramatic during the first several years of life.

The infant brain grows very fast. In brain the occipital lobe processes visual information, and the temporal lobe is responsible for hearing and language.

The adolescent brain undergoes dramatic changes during adolescence (Fig.4). Although it does not get larger, it matures by becoming more interconnected and specialized [42].

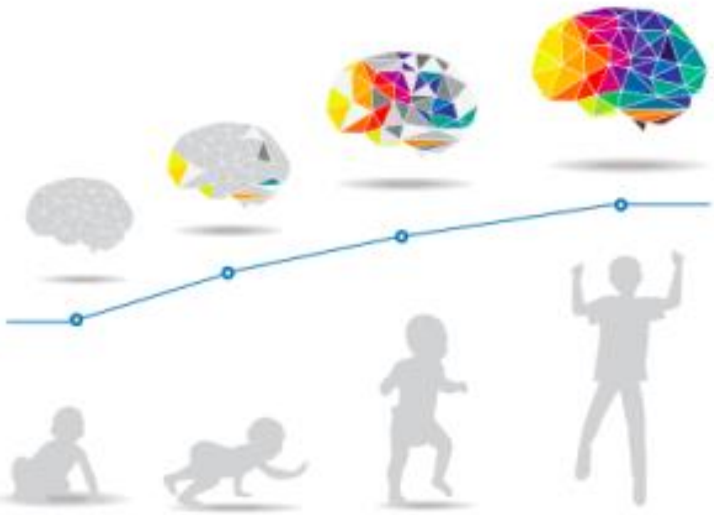

Figure 4. The brain reaches its largest size in the early teen years, but continues to mature well into the 20s.

Even as the connections between neurons are strengthened, synaptic pruning occurs more than during childhood as the brain adapts to changes in the environment. This synaptic pruning causes the gray matter of the brain, or the cortex, to become thinner but more efficient.

The brain does not keep getting bigger as you get older, but that does not mean the brain is done maturing; the teen brain is ready to learn and adapt; many mental disorders appear during adolescence; the brain is resilient.

In Discovering the Brain [43], Ackerman discussed major structures and functions of the brain, the role of the brain in mental illness, the development and shaping of the brain, from perception to attention, learning, recalling, and thinking, etc. She researched brain develop and function, and its complexity, sometimes tragically degenerate. Steinberg searched a social neuroscience perspective on adolescent risk-taking [44].

In the 1960s and 1970s, Kandel, et al., argued that learning does not build new connections to neurons, but strengthens existing pathways. Non-declarative memory does not require any special neurons or organs. While long-term memory includes changes in the neuronal structure and the LPT. The two are the existing and the newly formed respectively. The hippocampus is one of the few areas in the brain that can grow not only new neural connections, but also entirely new neuronal areas in adulthood. New formation can be found in the hippocampus.

It is known that brain tissue produces a large number of neurons during its development, much more than the brain can use in the future. This process of "flowering" will undergo massive "pruning" during adolescence. Some areas of the nervous system can even lose 85% of the neurons. Our experiments have proved that some non-ocular vision children can see infrared light [45,46]. The death of some neurons and cells in this process will lead to the loss of certain functions. If these are invariant, the corresponding function can be maintained. Further, we may compare the differences between children and adults, and can identify these cells and neurons. Thus, identifying brain cells at different time periods can determine different functions. And it can be used to treat diseases of different periods, such as senile diseases. It can be used in artificial intelligence AI.

5. Blind Vision and Brain Plasticity

It is known that primary visual area V1 may pass through V2, V3, V5 continuous processing [47]. Blind people not only apply DLPFC and IPS of brain in recognition, but also apply many brain areas in the visual cortex: occipital lobe, lateral occipital cortex (LOC), middle temporal gyrus (MTG), inferior temporal gyrus (ITG) and FG [47].

Drawing on behavioral and neurophysiological data, Cattaneo and Vecchi analyzed and investigated the effects of blindness and other types of visual deficit on cognitive abilities. They researched on mental imagery, spatial cognition, and compensatory mechanisms at the sensorial, cognitive, and cortical levels in individuals with complete or profound visual impairment, and found that our brain does not need eyes to "see", and examined the effects of blindness and other types of visual deficits on the development and functioning of the human cognitive system []. They addressed critical questions of broad importance: the relationship of visual perception to imagery and working memory and the extent to which mental imagery depends on normal vision; the functional and neural relationships between vision and the other senses; the specific aspects of the visual experience that are crucial to cognitive development or specific cognitive mechanisms; and the extraordinary plasticity of the brain—as illustrated by the way that, in the blind, the visual cortex may be reorganized to support other perceptual or cognitive funtions. In the absence of vision, the other senses work as functional substitutes and are often improved. They pointed to the importance of the other senses in cognition. This is a great work.

Numerous studies have found that congenitally blind individuals have better verbal memory than their normally sighted counterparts. In order to distinguish between these possibilities, Occelli, et al., tested congenitally blind participants and normally sighted control participants, matched for age and education, on a range of verbal and spatial tasks. Congenitally blind participants were significantly better than sighted controls on all the verbal tasks but the groups did not differ significantly on the spatial tasks. Thus, the congenitally blind appear to have superior verbal, but not spatial, abilities. This may reflect greater reliance on verbal information and the involvement of visual cortex in language processing in the congenitally blind [49].

Shafique, et al., studied that blind people use different navigational strategies to encode the environment. Path integration significantly influences spatial navigation, which is the ongoing update of position and orientation during self-motion. This study first highlights the significant role that the absence of vision plays in understanding body centered and proprioceptive cues [50].

We think that other hearing, touch can be reached through other ways to V2, or V3, or V5, etc. Such as primary auditory area A1 connects directly to the adjacent secondary visual area V2, V3, V5. Others senses are similar. Primary somatosensory area S1, primary gustatory area G1, and primary olfactory area O1 to V2, V3, V5. It is namely the Six Sense-organs Intersubstitution on eye-ear-nose-tongue-body-thinking in Buddhism, which as a type of special functions in fact is not strange [51,52].

Brain plasticity shows amazing adaptability. This can be corticocortical connections, and forms the multi-pathway, and arouses the part of the lateral occipital cortex (LOC). The brain is plastic throughout the human life, and obeys also obey the use it or lose it principle [47].

New functions are new transformations, and more likely new connections. Synaptic plasticity can be the long-term potentiation (LTP). LTP may promote synaptic plasticity, and form a new visual network.

Some animals can see the infrared light. Its development is namely that some children can be recognition words by non-eye sense, such as X.N. Jin can observe the infrared light by his "eye". They should have a visual network similar to these animals.

6. Possible Tests on Transformations among Vision and Other Sensations

According to the areas of cerebral cortices (Fig.5) [53], the sensation cortices include visual cortex (17, 18, 19, etc., area), hearing cortex (41, 42 areas), taste cortex (43 area), olfactory cortex (28 area), body sensation cortex (1, 2, 3 areas). But, it is a linear reductionism that different areas are distinguished. Olfactory nerve joints with optic nerve, and vestibulocochlear nerve relates to hearing. Gustation and olfaction are related closely. Gustation relates to thalamus, hypothalamus and amygdala, and they relate also to channel of olfaction into nerve centre.

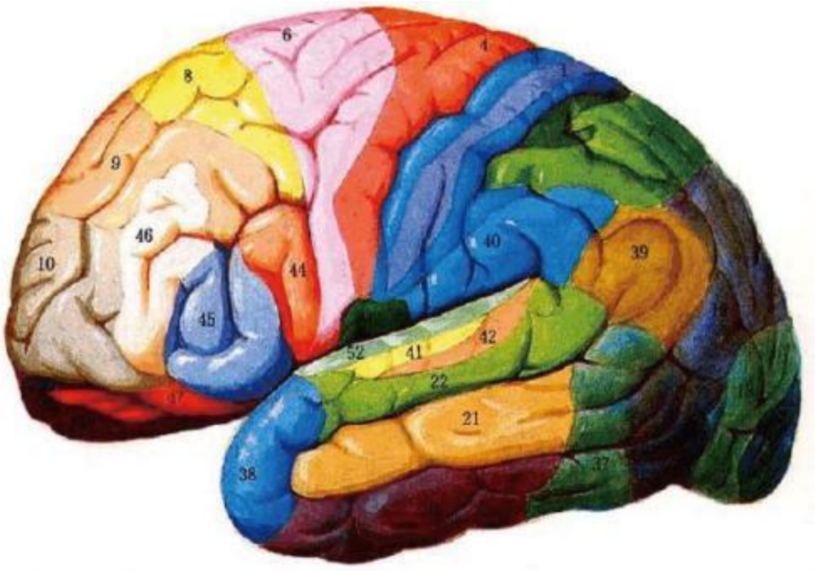

Figure 5. Physiological structure and functional partition of the human brain

In modern neurobiology various general independent sensation systems may be substitutions each other. For example, Bach-y-Rita, et al., researched vision substitution by tactile and tongues [54-56], etc. In a word, since half tissues of brain are in contact with vision, men see by their brains, and are not eyes [57-59]. It is related with the synesthesia [58-61].

Yoshioka and Sakakibara defined sensory transduction as energy transformation on seeing, hearing and smelling from the external world to the internal world [62].

In the summers from 2012 to 2017, we had trained fifty-two blind children in Kunming by combining traditional Chinese culture and adopting the method of guiding blind children to attain a quiet and focused state. Then, it was found these trained blind children could develop some special functions [63,64]. In this process, we noticed the synchronization which is a combination of telepathy and resonance. A blind child, X.N. Jin was particularly prominent. He not only accurately recognized dozens of poker points and colors on a Kraft paper envelope, but identified all cards, accurately pointing out single-sided graphics, and even double-sided multi-color graphics. Sometimes, he could even conduct PK successfully. Furthermore, on 6 August 2019, the research team witnessed X. N. Jin see the infrared light using his hidden "eyes" [51,52]. The whole process was conducted using scientific instruments to explicitly confirm that his vision had elevated and was sensitive to the infrared spectrum.

Based on these training results and modern neurobiology, we proposed a testable scientific hypothesis: The neural excitable cell is continuously induced and excited, then grow out new synapse and dendrite, so the feeling system, hearing system, smell system, etc., may joint to visual system, and form a new neural network, and achieve finally a transformation among vision and other sensations. Further, we proposed some possible tests, for example, scientists may train the blinded animals (such as mouse), then dissect their brain, and compare their different functions and different results. And these results may compare with those animals lack some sense organs. If this hypothesis is validated, it will bring benefit to mankind, in particular, disability, and may build a bridge between modern medicine and parapsychology, and between science and religion [51,52].

In training potential of blind and general children we found the synchronization, whose network model is [65,66]:

$$x_{n+1}(i) = f[x_n(i), y_n(i)] + k[1-\delta(i,n)] \sum_{j\in S(i)} \delta(j, n-\tau(d_{ij})), \quad (9)$$

$$y_{n+1}(i) = y_n(i) - \mu(x_n(i)+1) + \mu\sigma, \ (i = 1,2,\dots,N_1). \quad (10)$$

Here k is key, and k is bigger, the synchronization is stronger. It is a telepathy, and resonance of the thought field [67]. The same frequency of the thought field is easy to synchronize. Quantum entanglement among living things produces their synchronization and magic special functions.

They may form a new neural network [68,69], and prove a well-known degeneracy in the neural circuits proposed by Edelman [70], in which neural circuits of different structures may produce the same function. This is a classical neuronplasticity. It may prove the recurrences or loops in brain [71], or general neural circuits in modern neurobiology. It is also the brain plasticity and the synaptic plasticity, in which there has long-term potentiation (LTP).

Its base is the synaptic plasticity [72], and general plasticity of visual system for very young mammal, for which there has a critical period [73-75]. The adult mammal has also the visual plasticity [76,77]. Zohary, et al. [78] and Thoenen [79] investigated neuronal plasticity. Chino, et al., discussed four possible neural joints of visual system [80]. These joints all originate from retina. Synaptic responses undergo short- and long-term potentiation (LTP) of long-term changes of synaptic efficacy [81].

It is known that in the forepart brain grows to form new synapse, and for baby this jointed numbers are very big than adult. Then these synapses have an elimination period, or a shear period, and some superfluous joints will die out. In 1970s P. Huttenlocher collected various postmortem brains of different ages, and observed that prefrontal cortex for baby is different. The synaptic numbers of brain sensation regions for small-fry metaphase achieve mature level, and synaptic numbers of prefrontal cortex increase continuously, and then begin decrease. But, recent scientists found some brain regions, in particular, prefrontal cortices grow still for youthhood even then, and they will come through great change for former twenty-thirty years of life [82].

This is related to the mechanism of information processing by visual cortex. Pessoa, et al. [83], subdivide visual processing into low-level, intermediate-level, and high-level components. LTP is a persistent increase in synaptic strength, and occurs in a variety of neural synapses. It possesses "classical" properties: cooperativity, associativity and input specificity [84,85].

Based on various known characters of brain, we conjecture that the key regions of the transformation among vision and other sensations are cortex and its hippocampus, which connect to olfactory cortex. Some regions of total visual system are damaged or blocked, their results are visual barrier. But, it is usually unable that total system, in particular, brain part, destroys. Majority of blind originates from retina damaged. Therefore, the damaged parts are different, the cure ways and training effects are also different.

Under inducement or outside excitation various sensation systems may joint each other. Their basic principle of internal growth is the biological power of self-adjustment, self-repair and self-organization, especially for children. They all are nonlinear interactions. It corresponds also to the adaptability of brain. In physiology these are the transforms of different receptors of special senses for changed energy and coding. For example, fingers may have visual cells. Distances between ear, nose and eye are closer. Their nerves may probably joint to visual system, and produce visual effect. We may excite the corresponding auditory system by music and song, etc.

The robustness of brain may keep the whole and colligation of various sensations (hearing, vision, etc.), and derives a unified conclusion. Usual channel of sensation systems is labeled line. Only retina irradiated by light may produce vision, and neuron by mechanical or electric excitations in visual channel may also produce vision, but it is distorted. Coding process and adaptive mechanism of receptor are all very complex. For instance, the adaptation of rod and cone is related to change of their chemical elements, and adaptive production is related to change of some functions of synaptic transmission and sensory centre in the channel.

It corresponds to that sodium channel excited by action potential make an activation state from standby state. Adult corresponds to no-live state, so their some functions lose.

A type of testable experiments is: Scientists may train the blinded animal, for example, a set of young white mouse, then dissect their brain, and compare their different functions and different results. And these results may compare with those animals lack some sense organs, as shark and mole, etc. This test should be easy.

Children are lovely angels. Their growth is not completely to finalize the design, so their potentials open out easily. But, it must exist in a certain threshold, i.e., the training and excitation need a certain time. Adult growth is already to finalize the design, and various sensation systems are sclerosis and separated, so their potentials open out hardly. But a few adult has some joints among different sensory systems, congenial or through hard training. These may show the strong parapsychology. It suggests a possible application for blind agedness.

Some children train together, effects are better. It corresponds possibly to the population oscillation among neurons. There are the phenomena of synchronous oscillation among the visual cells. We may explore these structures of brains for trained men and some men with special functions. Further, if we collect various postmortem brains of these men, dissections will be able to test our hypothesis. This research is more general development in neurobiology. If this hypothesis is affirmed, it may even undergo surgery on the joint.

Hartline nonlinear equations describe the visual lateral inhibition phenomena. The phenomena are found not only in visual, and in hearing, feeling and other sensation systems. This is a commonness of various sensation systems.

This hypothesis must be based on the nonlinear whole biology [18]. Therefore, some possible theories are nonlinear equations, network, Hodgkin-Huxley equations and so on. Hopfield nonlinear equations [86] are:

$$C_i \frac{du_i}{dt} = -\frac{u_i}{R_i} + \sum_{j=1}^{n} T_{ij} f_j[u_j] + I_i . \qquad (11)$$

Here i=1,2,...n, $f_j[u_j]$ is the nonlinear function. They describe the dynamic neurons. From the equations Arbib and Amari described the network of neurons with competition and cooperation, which has a character of "winner taking all". When visual system is linearization, eye is first and engrosses vision. By a similar Hopfield method, the dynamical behavior of neural network combines the associated memory, and hearing, feeling, olfaction, etc., are combined to an attractor (e.g. apple), so the same result (apple) will be observed. It is also the parallel distribution processing (PDP) researched by Rumelhart, McClelland, Hinton, et al., in which the activation rule and change of coupling mode are consistent. Rall and Shepherd proposed new pathway of dendro-dentritic synapse in olfacrory bulb [87]. After such synapses are found.

In the neuronal model there are stochastic resonance (SR) theories, including Hindmarsh- Rose (HR) model, FitzHugh-Nagumo (FHN) model, Hodgkin-Huxley (HH) model, etc. SR corresponds to chaos. In 2003 T. Mori and S. Kai observed a stochastic resonance phenomenon in the visual processing areas of the human brain. SR is instructive in the treatment of diseases such as sensory disorders [88]. SR should be used for the blind person. In 2024 Spence and Stefano focus on the translation between audition and vision based on the narrative historical review [89].

7. Neural Network and Quantum Neuroscience

Georgiev proposed that quantum coherence forms the physical basis of life by interdisciplinary studies [90]. It may be that coherence leads to life, and the coherence corresponds to nonlinearity, which is related to the nonlinear whole biology [18]. Neurons, glial cells, and other physiological units can all be biological quanta. The basis is the general quantum coherence and quantum entanglement.

Consciousness is a macroscopic quantum theory [91]. Panpsychism shows that except matter-energy-information, world must add mind, psi, etc. This not only corresponds to dualism, and is both aspects unification and the neutral monism, i.e., Chinese traditional Lu-Wang Mind Philosophy (mind=matter).

Based on the neural networks, theory focuses on neurons, and Walter Freeman has observed in the laboratory that a large number of neurons will suddenly simultaneously switch from one complex activity pattern to another, in response to minimal input [92]. This is a quantum change. Ghirardi, et al., proposed a unified dynamics for microscopic and macroscopic systems [2]. This should correspond to the extensive quantum theory [93].

At present, the best model for neurons and neural networks is Hodgkin-Huxley equation (1) and its generalization (2)(3), etc. The information processes of the nervous system are quantitative processes. Uncertainty of brain corresponds to wave-particle duality, quantum orbit, statistics, soliton-chaos and other duality [19,94]. These are basis of the quantum neuroscience.

Based on quantum biology and biological gauge field theory, we proposed the biological lattice gauge theory as modeling of quantum neural networks [95]. This method applies completely the same lattice theory in quantum field, but, whose two anomaly problems may just describe the double helical structure of DNA and violated chiral symmetry in biology. We discussed the perception of Neural Networks (NN) and the quantum neutral networks, which are related with biological loop quantum theory [96]. A three-layer connected model of NN is (Figure 6).

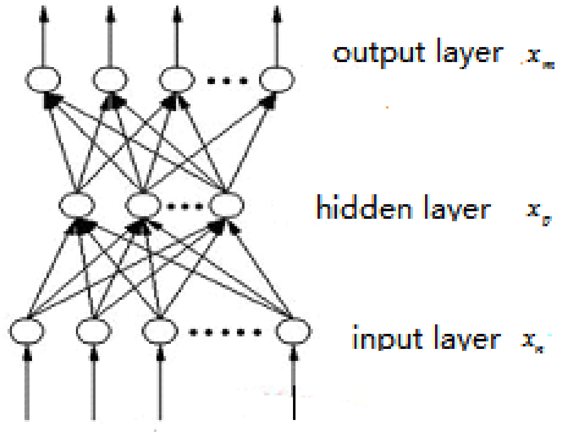

Figure 6. A three-layer connected model of NN.

In this model input layer x_n has *n* neurons, hidden layer x_p has *p* neurons and output layer x_m has *m* neurons. While x and y are not direct connection. The S matrix is a different labeling for incoming and outgoing states [97].

We introduce the quantum field theory in biology, whose goal describes the dynamics of interactions [98]. The S matrix as the scattering matrix is related between in-fields (in-states) and out-fields (out-states):

$$S_{\alpha\beta} = <\beta\ \mathrm{out}\,|\,\alpha\ \mathrm{in}>. \quad (12)$$

The S-matrix element is the Green's function for the r=n(out particles)+m(in particles) with the external legs removed. According to the principle of least action and the principle of maximum simplicity [98], the biological quantum field theory is constructed.

Biomathematics is a developed direction of modern biology. Recently, we researched its two new mathematical methods: the simple joint relation of algebra in set theory, and the tree-field representation and the extensive Feynman diagrams in the graph theory. We proposed that the Cambrian life explosion originated from unicellular to bicellular to multicellular can be explained by chaos. Based on the extensive quantum biology and the biological particles, we proposed the extensive quantum statistics of DNA and biology, and corresponding quantum equations. We discussed some new research of biology, such as the biological QED and QCD. Various levels in the biological systems have all laws with randomness and statistics, for which the most similar physical theory will be general quantum theory [99].

In conclusion, neurobiology, as a frontier of scientific development, not only has many problems to be solved, but also can greatly improve the conditions for human survival.

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