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The Generation of Semantics in Natural Language and the Formation of Brain Intelligence

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ABSTRACT

In nature, the foundation of life phenomenon is the abilities of representation, memory and behavior in life form originated from the motion and interaction between a great numbers of microscopic matters. Human natural language can describe and interpret this matter world, and naturally supports the subjective initiative of human. This paper emphasize that the language behavior also belongs to the category of general stimulation-response mechanism. Especially the brain neurons link with each other in 3D physical space, this forms the matter base of consciousness activity. It is well-known that the radial basis function representation principle is widely used in establishing the cognition ability such as representing color, sound, smell and gustation. For color representation, this paper uses a quantitative analysis method to approximately estimate the number of single wavelength color attributes that can be represented by human brain, and introduces some inspirational examples in color cognition. It is known that the simple neuron in the primary cortex is able to extract the direction information of a line, and analogously as the representation principle of 3 basis colors this paper introduces the representation principle of 3 basis directions which can represent the direction attribute information of a shorter line and can extract more topology structure attribute information of a shape through introducing the concept of event, and further construct more complex semantics. This paper emphasizes that the semantics in natural language exist in the neural fiber plexus nodes of brain, and also

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introduces some inspirational examples in shape cognition behavior. Note that human knowledge is represented through natural language; this paper also elucidates the principle of matter primacy. Through analyzing the evolutionary process of human intelligence, we have found that the subjective initiative of human in behavior is most important characteristic that distinguishes human from animal. In the end of this paper, we explain that why the brain consumes less power and the limitations of human intelligence.

Keywords: Brain intelligence; Conditioned reflex; Consciousness; Dissipative structure; General stimulation response mechanism; Neurons; Natural language; Radial basis function; Subjective initiative; Semantics; Sub consciousness

1. Introduction

Firstly, life form which is of a self-organizing system is also a kind of matter form. According to the principle of entropy increase in the second law of thermodynamics, an isolated physical system tends towards a disordered state. However, Maxwell's demon hypothesized by James Clerk Maxwell (1831-1879) attempts to confront the principle of entropy increase, and actually Maxwell's demon must have cognition and behavior abilities. Note that any knowledge involved in cognition ability always exists with some kind of structural form on the specific physical carrier, and then this will result in the entropy decrease of the corresponding system. Thus, the entropy of one life form that has cognition and behavior abilities is less than that of a disordered state of matter. In addition, in some type of dissipative structure (I. Prigogine, 1917-2003) which is of a non-equilibrium structure of exchanging energy, matter and information with external systems, we can observe the phenomenon of entropy decrease,such as that of Rayleigh-Benard convection. Note here that theabilities of general representation, memory and behavior are the essential characteristic of life form. For an example, during the initial stage of life form, the DNA of single cell canremember the structure of cell body, and based on a much vastand complex representation space that is a kind of available matter structure, a single cell can adapt to the environment through a large number of genetic mutations during a relatively short life cycle, and gradually evolve into animals with various physical characteristics adapting to different living environments in a relatively stable natural environment,and at the same time, it has also evolved a relatively complex brain neuron system, but no complex consciousness activity. Later, a critical period emerged, that is, humans walking upright began to manufacture and use tools. Note that humans are also a kind of matter form, and through using tools, broadly speaking, and the complexity of interactions between various matter forms increases greatly. It is exactly because ofthe use of writing- tools, humans can build a complete language system. Since then, humans are able to use natural language to represent the interaction, movement, and state of matters in a higher dimensional representing space. Here presenting the concept of general stimulation-response mechanism of brain, which indicates that the language behavior is also a kind of stimulation-response phenomenon in brain. With the natural language, attention and sub consciousness mechanisms, the consciousness stream which can display various complex

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scenarios and specific mind behavior can be formed through a great deal of behaviors.

2. The Characteristics of Neuron

In **figure 1** each neuron consists of a cell body that contains a nucleus. Branching out from the cell body are a number of fibers called dendrites and a single long fiber called the axon. The axon stretches out for a long distance, much longer than the scale in the diagram indicates. Typically, an axon is 1cm long (100 times the diameter of the cell body), but can reach up to 1 meter. A neuron makes connections with 10 to 100000 other neurons at junctions called synapses. Signals are propagated from neuron to neuron by a complicated electrochemical reaction. The signals control brain activity in the short term and also enable long-term changes in the connectivity of neurons. These mechanisms are thought to form the basis for learning in the brain, and then the neuron system forms the matter base of human consciousness. Most information processing goes on in the cerebral cortex, the outer layer of the brain. The basic organizational unit appears to be a column of tissue about 0.5 mm in diameter, containing 20000 neurons and extending the full depth of the cortex bout 4 mm in humans.

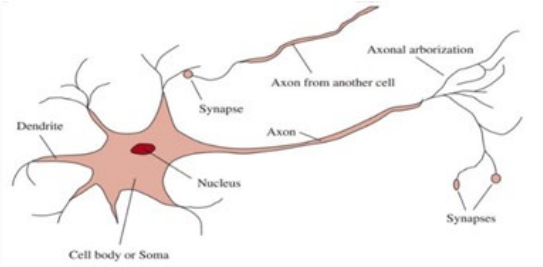

Figure 1. The parts of a neuron.

In the process of stimulation-response in one neuron, there exists a transient response zone, and if the total input voltage exceeds the threshold voltage of a neuron membrane, a fixed voltage level is output on its axon [1].

3. The Radial Basis Function and the Representations of Color and Sound Attributes in Neural System

3.1 The Representation of Color Attribute

On the retina, there are three types of cone cells that are respectively most sensitive to the light stimulations coming from three wavelengths that are 430 nm, 530 nm and 560 nm, and then forming three radial basis functions concerned with photosensitivity, namely 3 basis colors principle. In order to roughly estimate the ability of our eyes representing color attribute, we should note that the normal distribution is with the least amount of prior knowledge added to the model and then has the largest entropy, and then these 3 radial basis functions can be expressed as:

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$$y_k = \exp[-\frac{(f - f_k)^2}{2\sigma}], k = 1, 2, 3 \quad (1)$$

where yk denotes relative absorption rate of photons, σ is the standard deviation, and three frequency points f1, f2 and f3, f1 < f2 < f3. Here we reasonably assume f2 - f1 = f3 - f2 = 2σ [2].We all has known that through the ratios σ 1: σ 2: σ 3, the vision neural system can represent different color attributes. Here, to the stimulation coming from single wavelength light, when the corresponding frequency is in the intervals [f1 -2σ , f1], (f1, f2), f2, (f2, f3) and [f3, f3 +2 σ], the color attributes can respectively be represented by y1, (y1, y2), y2, (y2, y3), and y3, where, (y1, y2) and (y2, y3) denote the joint representations.

Note that for the above normal distribution, here for the convenience of analysis, assuming fk =0, then the area outside (-2σ , 2σ) is only 4.55% of total area. Obviously, if the total input stimulation energy has been normalized in certain form, then vision representation system to certain basis color should not be able to sense the stimulation from this specific region. Therefore, a reasonable probable number of stimulation energy representation levels are 1/0.05=20, and the number of different color attributes being able to be represented by our vision system could be such as 3+4×19=79. Seeing **figure 2**, although f2 - f1 ≠ f3 - f2 for human vision system, from our actual feeling the 79 color attribute representations already can sufficiently represent the visible spectrum.

Figure 2. The visible spectrum.

3.1.1. Color Constancy: Visible light in nature usually does not appear in the form of a single wavelength. In addition, the change of light brightness can generate the object shadow that is important in vision cognization, while it will result in the change of the attribute of the color observed; this increases a dimensional in the color attribute representation. Note also that evolution has enabled the human eye to perceive 9 orders of magnitude of extraordinary intensity (brightness); therefore we feel that there exist hundreds of thousands of color attributes. However, the brain always attempts to classify a color attribute of one object as its original color such as that displayed under the sunlight.

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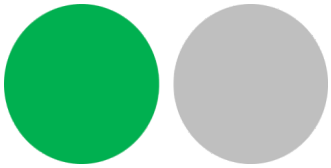

Figure 3. The after-image phenomenon.

3.1.2. The After-Image Phenomenon: In **figure 3** after staring at the bright green disc for about 5 seconds, turn your eyes to the gray circle next to it, and you will perceive that the gray circle has a faint purplish red which is the complementary color of green. It is generally believed that the principle of three basis colors cannot explain the after-image phenomenon. This also is a major academic debate that has been going on in the academic community for a century, and other theories different from the principle of three basis colors have also been proposed. Actually, when the subject perceives this color illusion, the brain scan results show that a lower visual area near the front of the V4 region experiences high-level activation that lasts for a period of time when the saturated color turns gray. Thus, we insist that when our gaze shifts to the gray disk, the brain only receives new stimuli from the complementary colors of green in gray.

3.1.3. White Balance Function: The vision neural system can perceive the change of spectrum structure of a light source; accordingly recover the original color of an object observed.

3.2 The Representation of Sound

Hair-cells in the cochlea have different lengths and then are respectively most sensitive to those mechanical waves with different wavelengths. The representation mechanism of the auditory system is analogous to that of the color system. In human spoken language, phoneme is the smallest phonetic unit related to the specific phonation mode, and human beings can only recognize about 100 phonemes.

4. The Representation of Object Shape

4.1. The Compound Eye of Insect

To obtain more information, most insects also have trichromatic vision like us, but they have a narrower visible spectrum width than ours (Menzel, 1979; Chittka, 1996). For a most characteristic insect, *anax junius* in dragonfly species has 28672 (approximately 170 × 170) small eyes in one eye and has the smallest small eyespacing angle among all insects. More importantly, to thecompound eye, the last synthesized image is of mosaic feature [3]. In addition, compared with human brain, the insect brain has much less neurons; it then can't remember the objectshape. However, with short-time memory ability this class of vision processing method based on a dot-matrix can be used in detecting the moving small target which results in a vision event to a dragonfly [4].

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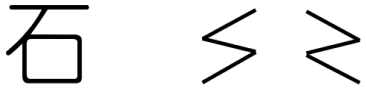
4.1.1. The Corneal Crystalline Eye of Human: This sort of eye is not popular in the animal kingdom. Although a human eye has approximately 260 million photoreceptors, but only 2 (approximately 1400 × 1400) million ganglion cells, i.e., the efferent cells of the retina which link to lateral geniculate nucleus, and finally most of the vision information will arrive at the primary visual cortex. Here note again that, when processing information the neuron system is most sensitive to change. In the primary visual cortex, Hubel and Wiesel found that the simple neuron, which links to a combination output of several lateral geniculate neurons, has selectivity to a shorter line orientation in the interval [-90°, 90°], and because of this discovery they won the Nobel Prize (1981). In the development of cognition ability, the radial basis function representation strategy is widely used in color, sound, smell and gustation. As the above analysis to single wavelength color representation with the principle of the 3 basis colors, here also in the primary visual cortex, through the representation principle of the 3 basis directions of such as that of -45°, 0° and 45°, the vision neuron system can approximately represent 79 different line directions in the interval [-90°, 90°]. Note that this kind of representation mechanism already can effectively extract and represent the direction attribute information of a shorter line, and also enable the simplest DNA expression. Here again applying the concept of vision event, note that at the inflection point position, a line segment direction changes distinctly, and the brain can cognize the occurrence of this vision event. Certainly the node and endpoint also belong to the category of basic vision events. Following the above analysis, through shape cutting and parallel processing mechanism, the shape in **figure 4a)** can trigger the corresponding vision events in the brain, and not as displaying a complex word in your brain, here in this case you can obtain a relatively clear shape display remembered in your brain. On the other hand, seeing the shape **figure 4b)** and in **figure 4c)**, they can only overlap by folding in three-dimensional space, and cannot overlap through rotation in two-dimensional space. However, when reading with faster speed, you can easily perceive the difference of the symbols **s** and □. Therefore, the shape topology structure including in various attributes becomes much important [5].



(a) (b) (c)

Figure 4. The example topology diagrams.

Today we humans can use natural language describe the attribute-representations introduced above. However, seeing **figure 5**, before the natural language appeared humans have already been able to draw animal shape and understand the semantics of each part in an animal body, and this belongs to a class of top-down representation behavior. Therefore, at that time these shape attribute-representations already can be formed in the neural fiber plexus nodes of the brain through observing the animal shape, and through combining more vision-shapes, then hieroglyph and symbolic language began to be developed since then.

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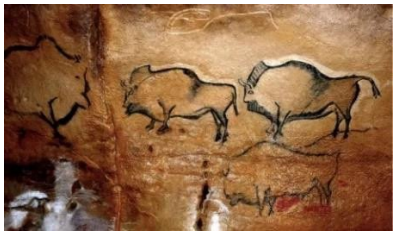
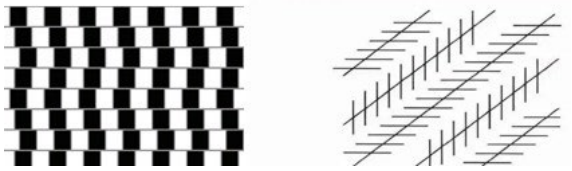


Figure 5. The cave painting in northern Spain about 40000 years ago.

In addition, when we see a familiar scene or text, the relevant semantics that have been memorized through learning will also be activated to some extent, we then can obtain more relevant information which actually comes from within the brain, and this is an important feature in human cognition behavior [6].

4.2. Gestalt Principle and Visual Illusion Phenomenon

The human visual system always tries to extract the most comprehensive and reasonable visual spatial structure, such as in **figure 6a) and 6b),** an inspiring explanation is that the brain is being interpreting this graphics in a three-dimensional space.



(a) (b)

Figure 6. In 6a) and 6b), parallel lines seem being no longer parallel,and we usually think it's due to visual interference.

4.2.1. The Attention Mechanism, Shape and Semantics: When you see **figure 7a)**, it is difficult to extract various semantics without any prompt. If prompted with the semantics of cattle, our attention then will focus on whether the neural fiber plexus nodes associated with the feature representations to various shapes of cattle in higher representation level are activated. Now, when you look at this picture again, through the visual system flexibly controlling the scanning behavior of your eyes, finally the corresponding neural fiber plexus nodes could be stimulated, and then the corresponding shape information of a cattle will also be displayed, while other shape information exists in the form of interference signals.

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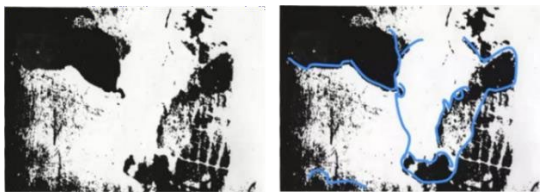
This process belongs to a class of bottom-up visual cognitive behavior. In addition, in **figure 7b)** there also exist the shapes of a fish and a human hand.



(a) (b)

Figure 7. The attention mechanism, shape and semantics.

4.2.2. Above the Shape -Grammar, Semantics and Knowledge in Natural Language: We humans are able to use natural language to describe and interpret this world that is filled with the motion, interaction and state of various matters named by us. In addition, natural language also is the operation system of our brain consciousness. For an example, through our learning with attention and sub consciousness mechanisms, we can extract the semantics in a text, and this behavior also belongs to the category of general stimulation-response which finally can form the consciousness stream. In practice, humans have mastered grammar rules through reinforcement learning, and a written language expression can be formed by the reasonable combination of some specific shape topology structures, such as a sentence. The experimental results (Hagoort et al., 2004, p.441) indicatedthat the brain takes the same amount of time to detect semantic errors and incorrect knowledge in a text; it is because both knowledge and semantics are expressed by using sentences, and naturally the brain must be able to recognize certain incorrect expressions about knowledge and semantics, and grammar error [7].

Through applying the fundamental matter attributes, we also can well explain some important mathematics concepts. For an example, for well over two centuries after imaginary numbers broke into the domain of mathematics, they remained enveloped by a veil of mystery and incredibility until finally based on physical space concept; they were given a simple geometrical interpretation by two amateur mathematicians: a Norwegian surveyor by the name of Wessel and a Parisian bookkeeper, Bobert Argand. Here, a multiplication operation between two imaginary numbers represents that theinteraction of these two symbols in space results in the rotation (motion in space) of a vector in a complex coordinate system. There eventually has the Euler formula that is the greatest formula in mathematics domain:

$$e^{j\pi}+1=0$$

5. The Origin and Development of Intelligence

The life forms themselves are a part of nature. In the process of a living thing interacting with the natural environment and each other, its instinct decides how to response to the external stimulations. Pavlov's conditioned reflex experiment revealed the relationship between stimulation and immediate behavior. The relationship between ongoing event and

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specific remembered event results in the sub consciousness phenomenon (Sigmund Freud, 1856-1939). Later, Skinner's (1904-1990) mouse box experiments introduced the concept of reinforcement learning which enables the animal's adaptability to the environment [8].

5.1. The Use of Tools Catalyzes Human Natural Language

When you see **figure 8** tens of thousands of years ago, humans walking upright began to have the ability to make and use tools; this also implies that human behavior has subjective initiative. Since then, the ability and complexity of human beings interacting with nature and each other increased rapidly, more and more complex semantics were constantly being displayed in thebrain, and through developing natural language system, human beings have greatly expanded semantics set that exist in a large number of neural fiber bundle nodes of the brain. Especially the development history of natural language is just abest example of humans applying subjective initiative. In addition, through our own introspection, we can clearly feel the spoken natural language is a kind of important inner speech in the brain thinking activities.

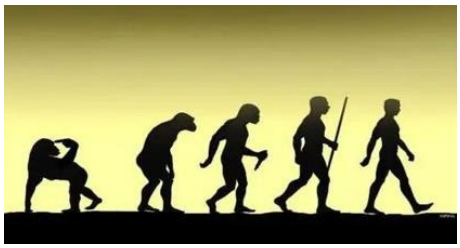

Figure 8. The evolution of human beings.

Even if don't understand grammar, the preschool child also can develop oral skills. It is because through extensive practical conversations, one child can induce the word- attributes such as noun, verb and others, and also can induce the rational sentence structure. With the human subjectiveinitiative to some extent, based on the rationality principle of natural language structure one child can understand and make up sentences that he or she had never heard before. Thus, the language ability of human beings is not innate; thesubjective initiative of human beings is innate [9].

5.2. Why the Brain Consumes Less Power?

The interconnections between neurons are achieved in thethree-dimensional physical space, then they are essentially based on connection rather than computation as that one computer does. Due to the attention mechanism, the brain once only activates less neuron. The threshold voltage of activating a neuron is very small, such as 70 mV, and the frequency spectrum width of signal stream is much small suchas 1 kHz. The myelin sheath wraps around the axon

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of one neuron, and forming a current insulator around the axon, then there is no electromagnetic interference problem. Therefore, the current flowing through a neuron can be much small. Based on the above analysis, the consciousness activity of human brain only consumes less power such as 20 watts even when dealing with a complicated problem.

5.2.1. The Intelligence in a Nutshell: So far, all the knowledge systems, which are constructed with different construction modes and contain only the partial matter attributes observed by us from the external world. Thus, all the human knowledge systems are incomplete, such as the Godel's incompleteness theorem. Perhaps, the natural number system is also not complete; it belongs to the category of metaphysics [10, 11].

To explore the more matter attributes, the autonomous artificial intelligence still needs to use tools, thus it cannot create intelligence miracles.

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