The Digital Linguistics: Three Breakthroughs in Speech Sound and the Adaptation/Exploitation of Sign Reflex Mechanisms for Linguistic Processing

Kumon Tokumaru

***Abstract*—The author hypothesises that the language of modern humans is a digital evolution of analog vocal sign communications of mammals based on in-brain vertebrate sign reflex mechanisms. Analog signs are frequency patterns. It is not easy to differentiate and share more than 100 different analog signs with respective meanings. Digital signs are generated by permutations of distinctive elements in frequency domain, phonemes, and it is easy to generate infinite and unique signs. In the brain, sign reflex mechanisms can be operated by immune cell networks inside the ventricle system. Antigen and antibody molecular structures constitute specificity pairs and cope with infinite sign waveforms or shapes. The author identifies that there are three evolutionary breakthroughs (BTs) in speech sound, namely, (i) the acquisition of phonemes and accents (or morae), which give distinctiveness in time frame, (ii) character set and literacy, and (iii) electronization and keyword search by computer networks. The author looks for how linguistic humans should improve themselves to cope with these breakthroughs.**

***Index Terms*—Digital evolutions, vertebrate sign reflex mechanism, immune cell networks inside the ventricle system, lifelong intellectual curiosity.**

I. Introduction: Human Language is Digital

Maynard Smith and Szathmary concluded in "the origins of life": The analogy between the genetic code and human language is remarkable. … in both systems a linear sequence of a small number of kinds of unit can specify an indefinitely large number of outcomes. … the discrete, digital nature of the units is probably necessary…It would be interesting to know how far these languages are digital.[1]

The author investigated and hypothesized that the language of modern humans is a digital evolution of analog vocal sign communication by mammals, which is supported by vertebrate spinal sign reflex mechanisms. Analog signs are frequency patterns and it is not easy to share more than 100 signs by animals, and thus the number of signs is limited. On the other hand, digital signs are generated by discrete phonemic permutations and thus it is easy to generate more than millions of unique signs.

The evolution from analog to digital signs is the acquisition of logical property, phonemes. Phonemes are distinctive phonetic elements in the frequency domain to be shared by linguistic community members. Each linguistic community has different and limited number of phonemes. By duplicate permutations, phonemes generate an infinite number of word signs

Manuscript received March 25, 2018; revised May 29, 2018.

K. Tokumaru is with Nissho Iwai Corporation, UNESCO, Nissho Iwai Aerospace Corporation – Europe Office, UNEP/NOWPAP Regional Activity Center in Toyama, Japan (e-mail: tokumaru@pp.iij4u.or.jp).

II. Acquisition of Phonemes and Morae (BT-I)

A. Recent South African Origin of Modern Humans

Statistical analysis of SNP (Single Nucleotide Polymorphisms) in mt-DNA and Y-chromosome revealed the origin of modern humans in Africa about 70KA, which coincided with the Toba volcanic winter (71-73.5KA). [2] Through analysis of African hunter-gatherers' mt-DNA, the birth place of modern humans is narrowed down to the coastal zone of South Africa. [3] While some linguists pointed out "considerable parallelism between genetic and linguistic evolution", and the Khoisan language to be the oldest, the two outstanding Neolithic industries in the South African Middle Stone Age (MSA) Still Bay (SB, 72-71KA) and Howiesons Poort (HP, 66-58KA) have not yet been identified and integrated into the hypothesis on the origin of language. [4]

It is partly because stone age researches from South Africa have been isolated from international consideration due to the international academic boycott from 1960s to 1990s, along with many South African archaeologists leaving their native country. It was a comprehensive isolation of both South African academics and journals. "At least eight manifestations of this boycott can be recognized: 1. Scholars refusing to travel to South Africa or to invite South Africans abroad; 2. Publishers, journals, and the like, refusing to publish South African manuscripts; 3. Scholars abroad refusing to collaborate with South African scholars; 4. Publishers abroad refusing to provide access to information (for example, books or computer software); 5. International conferences barring South Africans; 6. Institutions abroad denying South African academics access; 7. Institutions abroad refusing to recognize South African degrees; 8. Scholars abroad refusing to act as external examiners for theses presented at South African universities." [5]

MSA in South Africa started about 300KA probably with the use of fire for cooking. Hunter-gatherers foraged along the seashore for shells and fish, and probably cooked seafood over fire. As there are a lot of hollowed caves along this coastline, they started to use caves for their homes. Caves in the sea cliff at 20 m above sea level provided an extremely safe environment against enemies or predators. In such safe environment, new born babies can stay in the crib for at least one year without having to fend for themselves, and thus

doi: 10.18178/ijlll.2018.4.2.155

modern humans started to give birth to helpless infants.

Human babies are born in a helpless condition, which Portmann named "secondary altriciality" as primates are precocious. [6] Martin explained that the big brain size of anatomically modern humans is achieved by this helplessness in bed. Having spent 9 months in the mother's womb, a human infant is born helpless and stays in the crib for another year under intensive post-natal care while its brain size continuously grows at the same rate as inside the womb, i.e. proportionally with its weight increase. [7] The author surmises that this "secondary altriciality" was possible inside safe caves, thanks to intensive care of the child by other family members, mostly elder females.

Wilson provides general scientific arguments based on his study on the eusocial origins and evolution of the Hymenoptera, the insect taxonomic order that includes ants, bees, and aculeate (stinging) wasps. "Grouping by family can accelerate the spread of eusocial alleles, but it does not of itself lead to advanced social behavior. The causative agent of advanced social behavior is the advantage of a defensible nest, especially one expensive to make and within reach of a sustainable supply of food. ….. The second stage is the happenstance accumulation of other traits that make the change to eusociality still more likely. The most important is close care of the growing brood in the nest --- by feeding the young progressively, or cleaning the brood chambers, or guarding them, or some combination of the three." [8]

MSA already had (i) fire to cook, (ii) safe coastal caves for living in, (iii) secondary altriciality for a larger brain and (iv) eusociality to take care of babies. Apart from fire, these factors are not unique to modern humans and they all belong to background conditions where distinctive Neolithic industries suddenly emerged.

In the artefacts unearthed from Howiesons Poort layer, there were tool types which were only known from 'advanced' Upper rather than Middle Palaeolithic contexts in Europe, and the stratigraphic position (66-58 KA) of Howiesons Poort was clarified by excavation of the Klasies River Mouth main site. [9] Linguists have not yet taken this time-reversal seriously, which requires a Copernican turn from Eurocentric prejudice. It is necessary to realize the critical importance of logical properties of phoneme and vowel accented mora in speech sound stream, and hypothesize that linguistic humans were born in South African MSA.

B. Click Consonants as Phonemes

In Middle Stone Age (MSA) South Africa (300 – 25 ka), Still Bay (SB) and Howiesons Poort (HP) constitute two outstanding Neolithic industries in MSA period. The starting and ending ages for SB were estimated as 71.9 and 71.0 ka and, for HP 64.8 ka to 59.5 ka. [10] SB and HP emerged in the time series along the southern coastline of the African continent. The representative cave for SB is Blombos Cave, and those for HP are the Klasies River Mouth Caves.

Still Bay area is on a shallow beach. Klasies River Mouth Caves are located four hundred kilometers east of Still Bay, where waves are high and strong enough to erode extremely large caves at the mergence of the Atlantic and Indian Oceans. It is remarkable that the HP artefacts contain engraved ostrich eggshell containers. This sudden augmentation in the precision and sophistication of artefacts at SB/HP indicates that there were critical technological breakthroughs at the beginning of SB/HP periods, which probably was language. Precisely speaking, this SB/HP time series development of Neolithic industries should correspond to a two-stage development of logical properties in voice: phonemes, frequency domain distinctiveness, to generate an infinite number of word signs and moraic accents, to make individual syllables distinguishable. Thanks to accents, conceptual and grammatical syllables can be transmitted alternately without any remark, which enabled dualistic grammatical modulation of adjacent conceptual words.

In the past, it has been proposed that the so-called Toba event plunged the world into a volcanic winter, killing animal and plant life and squeezing our species to a few thousand individuals. However, the volume of vaporized flood basalts is 800km3, while at one of big five extinctions, at the end of Permian 250MA, the volume of flood basalts was in excess of 1.5 million km3, 2,000 times bigger volume than the Toba eruption. [11] It is not plausible that mass extinction should have taken place at the time of the Toba volcanic winter.

How can the coincidence of Toba volcanic winter with genetic statistical analysis and SB Neolithic industry be explained? The environmental stress of a volcanic winter, such as cold weather, less sunny days and less food, forced hunter-gatherers on the coastal zone of South Africa to spend more time than usual inside their caves, which functioned as sound shelters: they could sing as loudly and as long as they liked without being recognized by enemies or predators. A South African natural scientist, Marais spent a couple of years with wild chacma baboons and reported that chacma baboons were singing together in the evening and night for several hours. So why not modern humans?

"And then from all sides would come the sound of mourning, a sound never uttered otherwise than on occasions of great sorrow – of death or parting…… In the case of the chacma the condition also disappears with the settling darkness. When the troop finally moved on to the krans or to the entrance of the sleeping-cave, the games were resumed and sometimes on moonlight nights continued for several hours." [12]

It is probable that, through singing together, eusocial modern humans living inside caves autopoietically shared distinctive sound elements amongst their own community, which developed into phonemic click consonants.

C. Click Consonants and Laryngeal Descent

Deagling found that "no consensus exists that there is a diagnostic anatomical indicator for articulate speech in human evolution" and made extensive analyses to get clearer images of the evolution of the unique mandible of modern humans. He concluded that "high-frequency, low-magnitude loads associated with articulate speech are hypothesized to explain the apparent paradox of hypertrophied mandibular bone in contrast to the reduced bone thickness that typifies the remainder of the modern human skull." [13]

It is plausible that the frequent use of the tongue to produce click sounds had contributed to the modern human unique mandible and provided enough space to house the vocal tract

with its descended larynx. Lieberman also suggested that "before the evolution of the modern human SVT (Supra-laryngeal Vocal Tract), the neural substrate that sequences the motor pattern generators that generate speech must have been in place." [14] An evolution of a two stage development, click then syllable, seems appropriate.

Klasies River Mouth Caves (34.06 S, 24.24 E) are known to be the oldest modern human site. The extremely large hollowed caves face out toward where the Indian and Atlantic oceans merge, and were made in the sand stone layer by erosion by the strong waves. But "The Middle Stone Age at Klasies River Mouth in South Africa" reports the excavation work at KRM No.1 only. It did not introduce large comfortable caves 3 and 5. It is strange that Wymer contributed not a single word to this book, while Singer did not take part in the excavation work at all, probably neither in its drafting. [15] In fact, the excavation work was not completed, as Wymer suddenly returned to U.K. in July 1968 and never returned to S.A. again. [16]

Analysis of the KRM fossils, especially those of mandibles, are on-going by various researchers. At the conclusion of a comparative study, Royer stated that 'This study demonstrates that size variation in the Klasies River mandibular and dental samples is greater than in modern human populations, supporting the hypothesis that this MSA population was more dimorphic.' [17] The author presumes that the dimorphism in the Klasies specimens might indicate an evolution of a mandible taking place in this cave, which housed a descended larynx for vowel resonance.

D. Vowel Accented Syllables are Moraic Phonemes

Evidently the laryngeal descent seems to be critical to produce vowel accented syllables, containing logical properties of phoneme and mora. Deagling continued, "even though the chin is recognized as diagnostic of our species, its evolutionary and functional significance remain incompletely understood." To date, the relationship between clicks and vowel accented syllables has been an enigma. [13]

"Clicks are known as consonants involving a velaric ingressive airstream mechanism, whose geographic and linguistic distribution is restricted to Khoisan and a small number of other languages in Africa". [18] Clicks are the phonemes which can be produced without airflow, i.e. before the laryngeal descent and vowels. "Existing analyses of clicks and non-clicks are seldom integrated into a single coherent phonological system..." [19] This incoherency can be an evidence for the linear evolution of click-then-syllable. Once syllables were obtained, only the Khoisan kept clicks as they were surrounded by a world named by click based concepts, while those who left the area abandoned clicks as they had enough phonemes with syllables.

Westphal [20] concluded that, in "some of the Khoisan languages, most content words begin with clicks, but very few function words do." Content words are concepts such as nouns, verbs and adjectives. With phonemic permutations, sound symbolic conceptual words could be generated as much as they liked. Probably clicks were the first phonemes without any grammatical modulation capability. With accents, linguistic humans became able to vocalize conceptual and grammatical syllables alternately in speech sound without any remarks, which are integrated by the logic of dualism in the brain of listeners.

III. Language Faculty is Not in the Neocortex but in Ventricle System

A. Counterevidence for Language Area in Neocortex

The author identifies that there are three evolutionary breakthroughs (BTs) in speech sound, namely, (i) the acquisition of phonemes and accents (BT-1), (ii) character set and literacy (BT-2), and (iii) electronization and keyword search by computer networks (BT-3). And yet, the biological structure of our brain remains unchanged since the emergence of the linguistic human.

In fact, we have not yet identified cellular and molecular level brain mechanisms for linguistic processing. We don't know how we acquire a new concept and corresponding meaning, nor how our brains process language.

When our skull bone and duramater are removed, inside the arachnoid we see the neocortex. It has been taken as granted that between the Wernicke sensor and Broca motor areas, a synaptic connection should be established. However, after having experimented with a few thousand patients to stimulate the neocortex with electrodes, Penfield concluded that "Stimulation of the cortex has never caused the patient to speak or to become aware of individual words, although he may hear people talking and be able to understand what they say." [21] Pavlov removed the neocortex of dogs and confirmed that the conditioned reflex recovered. "As a rule the conditioned reflexes disappear after the operation, whether it is performed on one or both of the hemispheres and on whatever portion of them it is carried out. The absence of artificial reflexes persists for different lengths of time, varying from a single day to several months." [22] We had better look for an alternative organ and mechanism within the brain responsible for linguistic processing.

B. Inside Ventricle Immune Cell Network Hypothesis

The author hypothesized an intraventricular system immune cell networks for linguistic processing as well as sign reflex mechanism. According to Jerne, "immune system, when viewed as a functional network dominated by a mainly suppressive Eigen-behavior, but open to stimuli from the outside, bears a striking resemblance to the nervous system. Both systems display dichotomies and dualisms. The cells of both systems can receive as well as transmit signals. In both systems the signals can be either excitatory or inhibitory." Dichotomy divides the world into two, A or not-A, and executes memory based pattern recognition. Dualism formulates a logic which integrates two signals and produces an output, which can be used for grammatical modulation of an adjacent concept. "The nervous system is a network of neurons in which the axon and the dendrites of one nerve cell form synaptic connections with sets of other nerve cells. In the human body there are about 10^{12} lymphocytes as compared to 10^{10} nerve cells. Lymphocytes are thus a hundred times more numerous than nerve cells. They do not need connections by fibres in order to form a network. As lymphocytes can move about freely, they can interact either

by direct encounters or through the antibody molecules they release. The network resides in the ability of these elements to recognize as well as to be recognized." [23] B lymphocytes are mobile ad-hoc networking neurons.

Jerne stated that B lymphocytes have all the necessary functions to serve as concept devices. Jerne pointed out the analogy between language and immune system. "Looking at languages, we find that all of them make do with a vocabulary of roughly a hundred thousand words, or less. These vocabulary sizes are a hundred-fold smaller than the estimates of the size of the antibody repertoire available to our immune system." [24]

Jerne demonstrated that the vocabulary of immune system is a variety of specificity sets by antigens and antibodies, and that a hundred times bigger than vocabulary in languages and that it can cope with new signs. "I should now like to introduce some numerology into this discussion. How large is the number of different antibodies that the immune system of one single animal (be it a human or a mouse) can make? This number, during the past few decades, has been estimated, on more or less slender evidence, to exceed ten million, and this enormous diversity has been designated as the 'repertoire' of the B lymphocytes. Such a 'repertoire' has been characterized by Coutinho as 'complete'. 'Completeness' means that the immune system can respond, by the formation of specific antibodies, to any molecule existing in the world, including, as I said earlier, to molecules that the system has never before encountered." [24]

B Lymphocytes (= B-cells) provide essential biological mechanism for concept: (1) more than 10 million of specificity pairs can be generated between antigens and antibodies, (2) plasticity to cope with a new stimulus, (3) networking with antigens through mutual recognition, (4) conversion between analog physical shapes of speech waveform to three modules of predetermined amino acid sequences which constitute CDR (complementarity defining regions).

In the author's tentative definition, "concept" is "an in-brain device to represent a word memory and to connect in-coming stimulus and word memory, word memory and sensory memory, word memory and other word memories, word memory and thought memory". Molecular-biologically, it can be the microbiological immune cell with antibody networking with antigens and the networking memories.

C. Ventricle System

If word memories are not stored or processed on the neocortex, where are they? By integrating interdisciplinary researches, the author came to a conclusion that our consciousness exists as autopoietic microbiological immune cell networks inside Ventricle System (VS). It is microbiological phenomena regulated by the life logic of individual mobile neurons (= B lymphocytes) taking place inside the very low noise environment of Cerebrospinal Fluid (CSF) filtrated, purified and regulated by Chroid Plexus. If we want to enhance our intelligence, we had better understand logics and mechanisms of microbiological immune cell networks and the CSF environment so that autopoietic microbiological phenomena should develop and enhance our intelligence.

"The ventricle system is filled with CSF. CSF is weak alkaline and transparent aqueous solution. This fluid is filtered at the chroid plexus and fills the ventricle system, circulates the CNS (Central Nervous System), goes through the hindbrain median opening and hindbrain outside ports of the fourth ventricle and arrives at the subarachnoid space to be absorbed by the vein system." [25] CSF is the third circulatory system next to those of Blood and Lymph. The size of the VS is approximately 150 – 160 ml and about 500 – 600 ml of CSF is filtered every day by the choroid plexus at each ventricle: thus the CSF changes 3 – 4 times every day. Some medical textbooks explain that the role of the CSF is to protect the cortex against shock by it floating it inside the arachnoid. But if this is the only reason, the choroid plexus doesn't have to be located at Right/Left, Third and Fourth Ventricles, and the CSF does not have to change 3 – 4 times/day. Studies about the VS and CSF have not been so advanced, because they are located at a deep part of the brain, and because the CSF leaks out when the brain is dissected. Even state-of-the-art measurement equipment such as fMRI (functional magnetic resonance imaging) cannot provide images of the microbiological phenomena inside the CSF at this part of brain.

CSF is secreted blood sent in by the thick choroid plexus artery. The choroid plexus filtrates the blood and prevents large molecules from entering into the ventricular system, making the so-called Blood Brain Barrier (BBB). Because of BBB, lymphocytes and immunoglobulins were not supposed to be in the CSF. It has now become clear that they are present at the rate of 0.5% of volume in the blood, and perform active immune responses.

The route of the CSF passes through Frontal lobe, Corpus callosum, Fornix, Ventriculi lateralis (Hippocampus), Temporal lobe, Thalamus, Hypothalamus, Cerebellum, Medulla oblongata and Cortex at Subarachnoid. CSF comes into contacts with almost all parts of the brain, and connects the limbic system to the neocortex. This route is the "Information Super Highway" inside our brain, but there is no route map available with a detailed molecular structure of the ventricle wall probably because its importance has yet to be realised. This route demonstrates that the lymphocytes floating inside the CSF can network with any part of the brain.

D. Other Neuro-Immune Cells inside Ventricle System

Penfield investigated "Subcortical Interretationships", inter alia, the integral role and location of the reticular formation. "The reticular system of midbrain and diencephalons receives collateral connections from the ascending afferent systems before they reach the thalamus, as illustrated diagrammatically in Figure IV-2. Impulses are also received into the integrating network from various subcortical structures, …" [26] "Along this course are to be found specialized portions, centers, or nuclei, for the control of respiration, cardiovascular, and gastrointestinal functions, and for the control of posture and tone of the body as a whole (particularly the vestibular, pontine, and red nuclei, and the substantia nigra). A large portion of the lower brain stem, however, cannot be assigned any such specific function, and has been thought to subserve an important integrative

function, correlating the activities of the specific systems…"

Reticular formation is located at the center of our CNS. It "is known from embryology that most of the left over cells of the brain stem and spinal cord which are not concerned in the formation of motor root nuclei and purely sensory relay nuclei are utilized in the production of the formatio reticularis." [27]

There are neurons inside the ventricle system named as Cerebrospinal Fluid Contacting Neurons (CSF-CN). Neither neurologists nor immunologists study the CSF-CN, but they are reported in the journal of Histology. [28], [29]

CSF-CN are neurons connecting the retina/cochlea and ventricle wall, and their terminals at ventricle wall constitute antigen terminals with cilium of motor protein on the top. CSF-CN has functions to generate a new antigen terminal at the Brainstem Ascending Reticular Activating System (ARAS) corresponding to a new external sign stimulus.

On the other hand, about 90 % of brain cells are immune cells. Gray material which covers the surface of neocortex is microglia, which are very similar to macrophages which present antigen molecules on the surface of the cell membrane. Pavlov reported that signs should be given in prior to meanings to establish the reflex successfully: "it is also and equally necessary that the conditioned stimulus should begin to operate before the unconditioned stimulus comes into action. If this order is reversed, the unconditioned stimulus being applied first and the neutral stimulus second, the conditioned reflex cannot be established at all." [30] It is possible that, when a Microglia is newly matured in the Hippocampus with the memory of food to be coded in DNA double helix in the nuclei, antigen 3-dimensional structure representing sign waveform is presented on the cell membrane surface as an index. [31], [32]

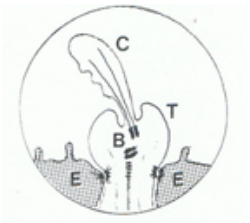

Fig. 1. Terminal & cilium of CSF contacting neuron [28].

E. Network Requirement Analysis inside Ventricle System

How ambient speech sound can be represented by antigen and antibody molecular structure. Phillips is reluctant to admit that cortex is involved in speech sound processing and stated that "the representation in the cortex of speech sounds is acoustic rather than phonetic, and is independent of voice pitch." And, "insofar as human speech sounds are concerned, it is unlikely that cortical neurons are able to entrain spikes to the glottal pulses that set the voice pitch, but there is no doubt that they can indicate the timing of the phonetically important components of the speech signal. In this regard, there is recent evidence that the most important temporal components of the speech signal are the slower, amplitude envelope fluctuations, rather than the waveform's fine time structure." [33]

The comparison between the slower amplitude envelope fluctuations and the waveform's fine time structure is available in Chiba. [34] After having measured fine time structure of frequency and amplitude, Chiba outlined the envelope. It seems that the envelope derives from multiplexed waveforms of amplitude (= intensity) and frequency (= pitch), and thus represent energy curve. It is plausible that 3-D structure of antigens should represent such envelope shapes.

The slower amplitude envelope fluctuations can be shaped as antigen presentation at Brainstem Reticular Formation by CSF-Contacting Neurons, the same antigen structure on the membrane surface of microglia cell on the neocortex, and antibody molecule with specificity pair to the antigen should be formulated on membrane surface of B lymphocytes.

Table-I is the result of Network Requirement Analysis for inside VS Immune Cell Networks for Word Sign Reflex. Antigen terminals of CSF-Contacting Neuron and Microglia Cell represent "amplitude envelope fluctuations" of individual phonetic stimuli of words. Antibody of B lymphocyte constitutes a specificity pair with the antigen terminal. Word phonetic stimulator (= CSF-CN) and Sensory memories related to that word (=Microglia cell) are mediated by conceptual device (= freely moving B lymphocytes inside CSF) for daily concept. The meaning of scientific concepts is to be established as network memories of dualistic thought operation among B lymphocytes inside CSF. This is a brief overview on the meanings of daily/spontaneous and scientific concepts. [35]

It is highly possible that the vertebrate sign reflex mechanism is operated inside the ventricular system immune cell networks amongst (a) cerebrospinal fluid (CSF) contacting neurons with antigen terminals at the brainstem reticular formation, (b) B lymphocyte floating inside CSF with antibody structures, and (c) glial cells on the neocortex with antigen terminals. If spinal sign reflex is based on immune networks, it can easily cope with millions of word signs. [24]

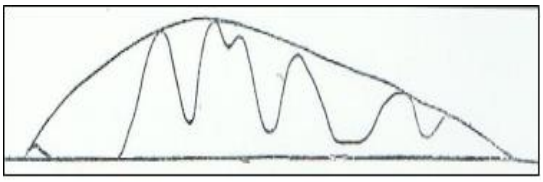

Fig. 2. Amplitude envelope fluctuation and fine time structure [34].

TABLE I: NETWORK REQUIREMENT ANALYSIS INSIDE VS

Network Requirement Analysis for Inside Ventricle System Immune Cell Networks for Word Sign Reflex

Nomenclature	Memory Type	Activation	Molecular Struture	Locaation	Mobility
CSF (Cerebro-spinal Fluid) Contacting Neuron	Sound Waveform of word phonetics (& Instinctive Reflex)	Activation	Antigen terminal with cilial vector	Brainstem Reticular Formation	Fixed
B lymphocyte (= Concept Device)	Word Networking Results and Waveform Receptors	Active / Passive	Antibody (= 3 Antigen CDRs)	Floating inside CSF (Cerebro-spinal Fluid)	Mobile
Microglia Cell (= Meaning of Daily Concept)	Sensory Memories with Sound Waveform as indexes	Passive	Antigen terminal to be recognized	Neocortex	Fixed

Table I shows that sensory memories stored in microglia cells are passive and to be recognized by B lymphocytes. For

example, when we happen to see our old friend on the street, we can recognize their face, but we cannot recall their name. It is because sensory memories are fixed in the neocortex, and they must be recognized by concept devices. A critical function of an amplitude envelope was confirmed when I said the word "Pakistan", then Ms. "Takeshita" reacted as she felt that her name was called. The similarity between Pakistan and Takeshita (pronounced with Japanese flat intonation) should be in the envelope shapes.

F. Monaural Audition for Grammatical Processing

With laryngeal descent, linguistic humans became able to vocalize vowels, which are powered by airflow from the lungs and have waveforms combining pitch (frequency) and intensity (amplitude). The vowel waveforms make syllables distinctive and moraic, which enabled grammatical processing.

Grammar are mainly mono-syllabic and onomatopoietic logical switches to modulate adjacent concepts. Thanks to vowel accented syllables, conceptual and grammatical syllables can be alternately transmitted in the speech sound stream without any remark. They seem to be dualistically integrated by a vertebrate sign reflex mechanism: pattern recognition of signs integrated with vector analysis of grammatical syllables.We hear our mother tongue monaurally and suspend the sound localization function in our brainstem auditory nuclei. It is plausible that the sound localization function takes care of grammatical syllables as sound vectors. The author surmises that this can be an answer to the Chomsky's conundrum: Why humans can compose an appropriate new sentence in a particular situation, and, why, with hearing it only once, others can understand it immediately? [36]

IV. Character Set and Literacy (BT-II)

A. Civilization by Inheriting Linguistic Information

How could Neolithic stone culture develop into our modern technology such as mobile-phones and e-mails with photographs? Can it be explained as a linguistic phenomenon? Yes.

Person-to-person linguistic communication had been limited to only speech sound for more than 60 thousand years after the laryngeal descent, 66KA in South Africa. Then in Egypt and Mesopotamia, around 5ka, hieroglyph and cuneiform were invented as phonograms. Orthography defines the correspondence between phonetic speech and writing: the sound of speech can be recorded and retrieved from the alignment of phonograms. This character set and knowledge of orthography provided linguistic humans with an extended external memory system which could be shared and passed on as a tradition. Civilization can be defined as the "time and space where members can share linguistic information such as law, literature, technology, etc. and improve on this through the generations, thanks to character set and literacy". Or, another definition can be as follows: in a civilization, a person is expected to learn what the precedent generations have written down and to go beyond them. In our civilizations, modern humans became immortal by inheriting and improving common intelligence.

B. Evolution from Phonogram to Ideogram

Although all four ancient civilizations used character sets, it is only Chinese characters which have survived until now. There are more than 50,000 characters of ideograms, which represent individual meanings and can be exchanged without knowledge of pronunciation or orthography. In Chinese legend, it was Cangjie (蒼頡) who invented characters around 2650 BC by order of the Emperor.

In China, the first comprehensive dictionary, Shuowen Jiezi,(說文解字) was compiled 2,000 years ago, containing more than 5300 characters. Thousand Character Classics (千字文), a poem using 1,000 different characters used to teach Chinese characters, had been popular since the early 6th century and was exported to neighboring countries. It takes a long time to master Chinese characters and become a cultivated person, but in East Asia there is this cultural tradition. As Chinese characters are a unique invention, they should be shared by all linguistic humans.

Japanese kana syllabary is a set of 47 characters, which was invented to enable people to read the Chinese characters and take the simplified shape of Chinese characters. It is likely that angular shaped kana, katakana, began in the 9th century using the bamboo spatula pen, and the round shaped kana, hiragana, started in the 10th century for the cursive hand with a brush. Kana works as high-low transmission gears in learning Chinese characters. Thanks to these two syllabaries, the literacy rate in Japan is extremely high, although the Japanese writing system is said to be the most complex in the world.

C. Scientific Concepts in A Very Low Noise Environment

The etymology of "science" should be latin words "scire" (know) and "silentium" (silence), which indicates that we can reach a higher stage with silence. Copernican heliocentric theory and Mendel's genetics were both conceived in the extremely quiet environments of a monastery, where scholars could think repetitively and profoundly. Monks transformed religion into science. While "daily concepts" are connected to sensory memories obtained and systematized through daily activities, "scientific concepts" are generated through the accumulation of network memories of dualistic conceptual operations and can conceptualize subjects on a mega-scale such as astronomy or micro phenomena like genetics which is beyond our normal sensory experience.

The meanings of daily concepts depend on an individual episode or experience, which cannot be unified or fixed. On the contrary, the meanings of scientific concepts are to be created by the accumulation of dualistic conceptual operations. With appropriate and sufficient number of thought operations, the meanings of scientific concepts should converge and become precise.

It is necessary for us to put up with the period when scientific concepts are just "*signifiants*" (signs) without "*signifiés*" (meaning), and keep learning and thinking until the meaning of scientific concepts are clearly formulated and stabilized. For some complex concepts, we have to implement a lot of conceptual operations for months and years to end up with a refined and well examined meaning. At

this stage, scientific concepts can be logically defined in a transparent, step by step manner, to be exchanged, compared and shared. In principle, all scientific concepts must be logically and precisely defined to avoid unnecessary confusion and make for fruitful discussions. Definition is a tool to use concepts correctly.

When considering a complex invisible system, reference models are useful tools, conceptual diagrams indicating a relationship among elements. Examples are the schematic diagram of a general communication system [37] and the OSI Reference Model used in the computer networks. [38]

D. Diffusion of Linguistic Information beyond Time and Space

Stone monuments and clay tablets are heavy. They cannot be easily transported. With the invention of paper and ink, letters were exchanged. Printing technique enabled the publishing of books. In the 20th century, electric communication, radio/television broadcasting, voice/video recording, facsimile, etc., enabled the transmission of linguistic information beyond time and space: linguistic information survives beyond man's physical life and travels beyond frontiers.

V. Linguistic Information in Electronic Form and Computer Networks (BT III)

A. The Benefit of Interactive Keyword Search

Maynard Smith and Szathmary predicted, "The last transition, through which we are living today, is the use of electric means for storing and transmitting information. We think that the effects of this will be as profound as were those after the origin of the genetic code, or of language." [1] In the 21st century, much linguistic information is available in electronic form. If we put some keyword into Google or other search engines, within seconds they list the relevant linguistic information, which can be immediately accessed or downloaded. The Open Public Access Catalog (OPAC) of libraries indicates which libraries hold the books we need (even down to the exact shelf location) and we can find new and secondhand books on the web to be paid with by credit card.

A lot of copyright free books, scientific papers and useful linguistic information can be downloaded as PDF or text files free of charge. We can access them with our smartphone or laptops from anywhere in the world. It is necessary to enhance our brain capability to learn more words and to think more to advance human collective intelligence.

B. Beyond the Restriction of Memory Based Reflex

As our linguistic processing mechanisms are based on the vertebrate sign reflex, it is a memory based system. When we have a word memory receptor in our brain from before, we reflexively react to that word without confirming if the word is used within its ordinary meaning or not, which causes misunderstanding in our everyday life. We misshear words we don't know, regardless of its importance. We should pay attention to all words and spot which are new to us or which are used in unfamiliar context.

Against a new word, a specific new receptor and a concept device must be generated to recognize it. Probably it is a maturation of neuroblast cell, triggered by an order to do so issued by our bodily immune system. (Immune cells develop from neuroblast cells.) Then, to acquire the general meaning for a daily concept, it is necessary to normalize and standardize one's peculiar episode memory in time and space. To establish a transparent and appropriate definition for a scientific concept, intellectual enthusiasm with continuous learning and countless thought is required.

C. Ego-Centric and Equilibrium Oriented Nature of Our Consciousness

Piaget pointed out that our intelligence is ego-centric and once it reaches the stage of equilibrium, it easily assimilates a few exceptions. [39] We determine what is right or wrong based on what we already know. It is an egocentric mechanism and we cannot assume its validity.

Sign reflex is self-sufficient mechanism, and not open to a new field. It is envisaged that we have to keep being curious against what we don't know and always be open to new situations. Zen and contemporary art have been struggling to overcome the restrictions of reflex. Zen quest for meditation, koan, refuses any common sense answer. Nonsense *objet* (not *pièce*) in contemporary art are presenting opportunities to open our eyes in a new world: we stop reflexes, just gaze at an *objet* liberated from prejudice and try to be acquainted with its world. To cope with a new word and new meaning, we had better follow the way which *koan* of Zen and contemporary art are presented.

D. Forward Error Corrections (FEC) of Linguistic Information

Like scientists, human babies are keen to know everything. They have an innate intellectual enthusiasm and curiosity. However, we lose such intellectual curiosity when we become adult. It is probably because sign reflex is a self-satisfactory recognition mechanism. Or, we are too contaminated, confused and exhausted to look for something new and interesting. We tend to look for what we already know, but we don't look for what we don't know.

When we put keywords into internet search engines, thousands of relevant references are listed. We are flooded with linguistic information with an uncertain quality and reliability.

Forward Error Correction (FEC) is a technology in digital information processing to correct errors without contacting information senders or original authors. It differentiates errors in two, channel coding errors, for which authors are not responsible, and source coding errors for which they are responsible. They constitute excluded middle, and after channel and source coding error corrections, we can get error-free information.

At the time of receiving information, receivers should verify if it is authentically presented as the original author desired. Biography and other author's work are auxiliary information which confirm the reliability of authors.

Manipulation and apocryphal information are channel coding errors, which should be eliminated. The author can protect his text from forgery by adding additional analytical data as error correction codes. For example, Dogen (1200-1253) protected his texts Shobogenzo (75 volume

version) by stating the serial number, volume title, lecture date and place for each volume as a post script at the end of each volume. He also protected another text, Dogen Osho Koroku (Sozan-bon, volume 1-10), by counting the number of lectures and poems contained in each volume, written at the end of each volume.[40] Readers can verify the authenticity of the texts by these post script codes and disregard incorrect copies.

Readers should verify the accuracy of an authors idea by following a step-by-step learning and thinking process, i.e. unifying themselves with the authors. Without fully understanding the author's knowledge and way of thinking, readers cannot detect the authors' errors and correct them. Through continuous efforts to correct errors in texts, human intellectual genomes should be established for linguistic humans to inherit, share and improve as human collective intelligence.

E. Behave as Cosmopolitans

Modern humans are altruistic and eusocial, probably because we had to take care of altricial babies inside caves under the supervision of elder females. This is a legacy of the middle stone age (300 – 25ka) in South African caves, but it is not preferable for linguistic humans, who should be cosmopolitan and only seek the development of the human collective intelligence for the benefit of all living creatures.

VI. Conclusion: Human as Linguistic Product

Modern humans are linguistic animals. We must behave as linguistic humans, understanding the capability of digital language and overcoming the restrictions of our sign reflex mechanisms.

Acknowledgment

I am grateful for Prof. Takao Suzuki, who provided me with a lot of insights and enthusiasm to clarify the mechanism of language and modern humans. His linguistic theories on meanings and vacant signs, and his interdisciplinary study, "Vocal Communication in Bird: A Semiotic Analysis" (Linguistic Inquir, Vol. 30 (1956) pp30-45) provided me with an idea to investigate vertebrate spinal sign reflex mechanisms.

References

[1] J. M. Smith and E. Szathmáry, *The Origin of Life*, Oxford Univ. Press, 1999.
[2] S. Ambrose "Late Pleistocene human population bottlenecks, volcanic winter, and the differentiation of modern humans," *J. Human Evol*., vol. 34, pp. 623-651, 1998.
[3] B. M. Henn, *et al.*, "Hunter-gatherer genomic diversity suggests a southern African origin for modern humans," *PNAS*, vol. 108, pp. 5154-5162, 2011
[4] L. L. Cavalli-Sforza, *et al.*, "Reconstruction of human evolution:Bringing together genetic, archeological, and linguistic data," *PNAS*, vol. 85, pp. 6002-6006, 1988
[5] F. W. Lancaster, "The academic boycott of south Africa: Symbolic gesture or effective agent of change?" *Perspectives*, vol. 15, no. 1, Fall 1995.
[6] A. Portmann, *Biologische Fragmente zu einer Lehre vom Menschen* Basel: Benno Schwabe & Co. Verlag, 1944.
[7] R. D. Martin, *Primate Origins and Evolution: A Phylogenetic Reconstruction*, Princeton Univ., 1990.
[8] E. O. Wilson, "The social conquest of earth," *Liveright*, New York, vol. 19, p. 184, 2012.
[9] S. Wurz, "The Howiesons poort backed artefacts from klasies river: An argument for symbolic behavior," *South African Archaeol. Bulletin*, vol. 54, pp. 38-50, 1999.
[10] Z. Jacobs, *et al.* "Ages for the middle stone age of southern africa: Implications for human behavior and dispersal," *Science*, vol. 322: pp. 733-735, 2008.
[11] D. R. Prothero, *Bringing FOSSILS to Life – An Introduction to Paleobiology* , 2nd Ed., McGrawHill Higher Education, 2004, p. 87.
[12] E. Marais, *The Soul of the Ape*, Stephan Phillips, Africana Series 1969 pp. 105-106.
[13] D. J. Deagling, "The human mandible and the origins of speech," *J. of Anthropology*, 2012.
[14] P. Lieberman, "On the nature and evolution of the neural bases of human language," *Yearbook of Physical Anthropology*, vol. 45, pp. 36-62, 2002.
[15] R. Singer and J. Wymer, *The Middle Stone Age at Klasies River Mouth in South Africa*, Chicago U.P. 1982.
[16] Rudner, *Letters from John Wymer to Jalmar Rudner Dated 11 March*, Library of Univ. Cape Town, 14 May and 21 Sept. 1968.
[17] D. F. Royer, C. S. Lockwood, J. E. Scott, and F. E. Grine, "Size Variation in early human mandibles and molars from klasies river, south africa: Comparison with other middle and late pleistocene assemblages and with modern humans," *AM. J. Physical Anthropology*, vol. 140, pp. 312-323, 2009.
[18] H. Nakagawa, "Integration of the clicks and the non-clicks Area and culture studies," Tokyo Univ. of Foreign Studies, vol. 75, pp. 87-96, 2007.
[19] A. Traill, "Linguistic phonetic features for clicks," in, *African linguistics at the crossroads: Papers from Kwaluseni (1st World Congress of African Linguistics, Swaziland, 18-22, July, 1994)*, R. K. Herbert, Ed., pp. 99-117, 1997.
[20] E. O. J. Westphal, "The click languages of southern and eastern Africa," in *Current Trends in Linguistics, Vol. 7: Linguistics in Sub-Saharan Africa*, T. A. Sebeok, Ed., Berlin: Mouton 1971.
[21] W. Penfield and H. Jasper, *Epilepsy and the Functional Anatomy of the Human Brain*, Boston Little 1954.
[22] I. P. Pavlov, *Conditioned Reflexes*, translated by G. V. Anrep, Oxford Univ. Press, 1927, Lecture-19, p. 323.
[23] N. K. Jerne, "Toward a network theory of immune system," *Ann Immunol (Paris)*, vol. 125, no. 1-2, pp. 373-389, 1974.
[24] N. K. Jerne, *The Generative Grammar of the Immune System*, The Nobel Lecture, 1984.
[25] T. Tamotsu, E. Kawano, and Y. Haida, "Sensory organs in ventricle system: Paraventricular organ," *Comparative Biophysics and Biochemistry*, vol. 23, no. 3, pp. 143-152, 2006.
[26] W. Penfield and H. Jasper, *Epilepsy and the Functional Anatomy of the Human Brain*, Boston Little 1954, p. 163
[27] W. F. Allen, "Formatio reticularis and reticulospinal tracts, their visceral functions and possible relationship to tonicity and clonic contractions," *J. Washington Acad. Sci.*, vol. 22, no.16-17, pp. 490-495, 1932.
[28] B. Vigh, "The system of cerebrospinal fluid-contacting neurons," *Archivum histologicum Japonicum*, vol. 46, no. 4, 1983.
[29] B. Vigh, *et al.*, "The system of cerebrospinal fluid-contacting neurons. Its supposed role in the nonsynaptic signal transmission of the brain" *Histol Histopathol*, vol. 19, pp. 607-628, 2004
[30] I. P. Pavlov, *Conditioned Reflexes*, translated by G. V. Anrep, Oxford Univ. Press, 1927.
[31] Guo-li, *et al.*, "Adult neurogenesis in the mammalian brain: significant answers and significant questions," *Neuron*, vol. 70, May 26, 2011.
[32] M. S. Neuberger, "Memory in the B-cell compartment antibody affinity maturation," *Phil. Trans. R. Soc. Lond. B*., vol. 355, pp. 357-360, 2000.
[33] D. P. Phillips, "Introduction to the central auditory nervous system," in *Physiology of the Ear*, 2nd Edition, San Diego, Singular, 1991
[34] T. Chiba, *Research Into the Nature & Scope of Accent in the Light of Experimental Phonetics*, Fuzanbo, Tokyo 1935.
[35] L. Vygotsky, *Thought and Language* Cambridge, MA. MIT Press 1986.
[36] N. Chomsky, *Current Issues in Linguistic Theory*, Mouton: The Hague, 1964.
[37] C. E. Shannon, "A mathematical theory of communication," *The Bell System Technical Journal*, vol. 27, pp. 379-423/623-656, 1948.
[38] A. S. Tanenbaum and D. J. Wetherall, *Computer Networks*, 5 ed., Prentice Hall, 2011
[39] J. Piaget, *La Psychologie de L'intelligence*, Paris, Armand Colin, 1947.
[40] K. Tokumaru, *Dogen wo Yomitoku*, Tokyo, Fuzanbo Int'l, 2017.

Kumon Tokumaru was born in 1959 in Oita, Japan. LLB from Univ, of Tokyo.

He worked in the business field of satellite earth observation and satellite communication, in Nissho Iwai Corporation, UNESCO, Nissho Iwai Aerospace Corporation – Europe Office, UNEP/NOWPAP Regional Activity Center in Toyama. He published a book, "Dogen wo Yomitoku (in Japanese. Tentative translation in English: Reading and Understanding Dogen (1200-1253)" Fuzambo International, Tokyo, 2017. His latest a series of articles on "the Deep History of Human Language" (although it is in Japanese, web translation function might help you to read it) is available on a web magazine *Courrier Japon*. http://courrier.jp/columns/101724/

He visited the oldest modern human site in the world, Klasies River Mouth Caves in South Africa in 2007 by himself. Since then, he has been working on the Digital Linguistics, starting from the origin of language, i.e. acquisition of logical properties of phonemes and morae, toward the completion of linguistic evolution, i.e. establishment of human collective intellectual genomes. His presentation at the ICLLL 2017 was awarded as the best presentation in the session, as his hypotheses that the spinal sign reflex mechanism processes language in the brain and that it is the intra-ventricular immune cell networks were dynamic and daring.