**The CNS-independent consciousness system: the model system of all nature and the framework of all sciences**

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**Abstract**

This paper presents the unification of all knowledge and the framework of all sciences, so it goes the theory of consciousness, the method to measure consciousness, and the three keys of the Strong AI. “Logicality and non-absoluteness” is found out to be the intrinsicality of nature, so the “Fundamental Law of Nature” is discovered. Then, the “general methodology of research” and the “model system of nature” are developed to explain everything, especially consciousness. The Coupling Theory of Consciousness tells that nature has the MFEs (More Fundamental Element) that couple to show as material and consciousness, and the brain has a CNS (central nervous system)-independent consciousness system that couples to give off the consciousness signals, with their three excitation levels to show as memory, sub-consciousness, and subjective consciousness. As consciousness is not from neurons, the method to measure consciousness via NCC (neural correlates of consciousness) is to find out participants with the same kinds of consciousness systems. And make them to produce paralleled “conscious information processes” to filtrate out the “noise” neural activities, to obtain the “real” NCC data. Examining the property of consciousness may advance not only neuroscience and physics, but also cognitive science and AI technology. First, the “conscious information processing” model has shown that the Strong AI should process the beyond-domain concepts with a self-controlled intention, second, as the “general methodology of research” is just the other name of the “principle of cognition”, we have already known the running style of the Strong AI. Hopefully, we could develop the Strong AI technology to upgrade human civilization very soon.

**Keywords**

Logicality, non-absoluteness, coupling, singularity, general impact of nature (GIN), consciousness system, Thinking-Coupling (TC), nonlinear thinking, pattern of thinking (POT), mental twin, neural correlates of consciousness (NCC), general knowledge of reality (GKR), self-controlled intention, the beyond-domain concept, universal knowledge element (UKE)

1. **Introduction**

The physicist Dr. Erwin Schrödinger (Aug. 12, 1887 – Jan. 4. 1961) has noticed the severe diversification of science and worried about the future of science under the limitation of the human brain. He said in the foreword of his book *What is life*: “The unification of all our knowledge is an ultimate goal of our studies”.

Today, the system of science is very diversified, but because of missing the unity of science, the research fields are too segmented, and disciplines closely related cannot be well attached to each other. A well-noticed example is about psychology, neuroscience, and cognitive science, without a model to cover them together, how could they be theorized and attached to each other? That is what we do in this research. We have developed a model system of nature to theorize them and many more issues. In fact, it has summarized not only science but all our knowledge of nature.

Our team had started to summarize all human knowledge in the 1990s. We soon realized that the human mental processes have missed its explanation in both physics and biology, then, we have kept focusing on examining the difference between linear thinking and nonlinear thinking in all following years. We had accumulated quite some new basic understandings of nature, but the crucial progress had not been made until we had discovered the method to measure the consciousness signals at the end of 2017, then, we started to write this paper to systematize our ideas.

1. **Methods**

This study offends no ethical rules since it is a generic study of humanity, and it is too theoretical to touch any personal information.

Our methods are to observe the difference between linear thinking and nonlinear thinking to investigate the mechanism of human mental processes. We have major examined our own mental processes and compared them with others from all perspectives in three decades. The study covers many aspects, such as human behaviors, reasoning courses, patterns of thinking, intelligence quality, and the personality and intelligence evolvement in generations. We set up models to explain, and to test those models from all aspects. Then, we observe and set up further models based on those verified models, on and on. We have gotten quite some new basic understandings of nature and science, especially the “general methodology of research” (subsection 3.1.5), so we have a mature law of reasoning, and please check subsection 3.1.5 for the detailed explanation. However, to put our methods in simple words, Dr. Douglas R. Hofstadter (Feb. 15, 1945- ) had an indication in his book GEB: “Current hard problems of science can be solved easily with a higher level of abstraction”. Getting a higher-level abstraction of nature is what we have kept trying and securing.

1. **Results**

We have got only three results: first, the unification of all knowledge; second, the model system of nature; third, the method to measure the consciousness signals. However, we need quite some words to explain them.

* 1. The unification of all knowledge and the framework of all sciences

3.1.1     The intrinsicality of nature

The intrinsicality of nature refers to the basic property of nature. As the change of everything can be only described by two words: logical and nonlogical, we have discovered that the intrinsicality of nature is “logicality and non-absoluteness”, and we use “non-absoluteness” to stand for “nonlogical” in physics. This is NOT either a hypothesis or an axiom but rather a logical conclusion. This discovery is so powerful, and it has not only provided the unification of all knowledge, but also enabled us to develop the framework of all sciences.

3.1.2        The Fundamental Law of Nature

The intrinsicality of nature has given us the Fundamental Law of Nature that all natural laws have to follow: “All changes of all phenomena follow some kinds of rules, all the rules are not absolute but on conditions, all types of conditions are not absolute either, but have their own ranges as well”. In simple words, all laws are not absolute but have their boundary conditions, and those conditions are not absolute but have their own ranges too. We see that conscious phenomena have to follow this law too.

3.1.3        The Fundamental Theory of Science

Scientific theories are our descriptions of natural laws. So, the “Fundamental Law of Nature” has given us the “Fundamental Theory of Science” that all theories have to follow: “All scientific laws in all theories are not absolute but only valid within their boundary conditions on their variables, and the boundary conditions themselves are not absolute either, but have their own ranges too.” In simple words, the “Fundamental Theory of Science” is “Any scientific theory shall clearly state its boundary conditions, otherwise, it is a wrong one or at least incomplete.” We see that the theory of consciousness has to follow this theory too.

3.1.4   The General Impact of Nature

As nature’s two most typical “nonlogical” behaviors are: a) appear the opposite suddenly; b) appear completely different suddenly, we believe that nature has a more fundamental impact that is vibrating-alike, say impacting with reverses suddenly and impacting with amplifications (or attenuations) suddenly. And as conscious phenomena are beyond space and force, we believe this more fundamental impact is beyond force, space, and mass. We call this impact the GIN (the General Impact of Nature), and call GIN’s “vibration beyond space and force” the Coupling.

As “force” is only a conception of modern physics that based on human sensations, say a point-to-point impact in space between two mass points, we assume that “force” is only one of the singular behaviors of the Coupling.

3.1.5      The general methodology of research and the holistic view of nature

Science is to know nature, so it is good to establish the “general methodology of research” to develop the “model system of nature”, and to have the framework of science. The intrinsicality of nature has concluded the basic property of nature by two points: “logicality and non-absoluteness”. “Logicality” refers to the systematicness of everything, from all views of physical, phenomenal, and virtual; “non-absoluteness” refers to the wholeness of nature and all things, from all views of physical, phenomenal, and virtual. After digested about these, we have developed the “general methodology of research” as below:

The general methodology of research:

Wholeness

Non-absoluteness

Generality

Boundary conditions

Alienation

Intrinsicality of nature

Systematicness

Logicality

Perspectives

Elementarization

Hierarchy

Fig.3.1.5.1 The general methodology of research (it is also the principle of cognition)

As “logicality” refers to the systematicness of an entity, we see that the study of all entities shall follow three concerns: “hierarchy, elementarization, and perspectives”. Let us explain them below:

1. “Hierarchy” is the basic form of systematicness, and it means to describe an entity with a hierarchical tree.

So, in this research, we have developed a three-layer hierarchical tree to describe nature like this: first, as neutral monism, nature has material and consciousness as its two “elements” (or subsystems); second, the intersections of material and consciousness have given off the life phenomena, and we choose human brain as the core sample, and see that the brain has two “elements” (or subsystems) as the CNS and the consciousness system; third, the consciousness system gives off the conscious phenomena, we see that the consciousness system has produced the consciousness signals in three transformable groups, which is known as memory, sub-consciousness, and subjective consciousness. So, they can be considered as the three “elements” of consciousness. And this three-layer hierarchical tree can be understood as the general model of nature.

1. “Elementarization” is the basis of hierarchy, and it means working out the critical points.

“Elementarization” can be done with entities’ two opposite characters. That is why we elementarize nature with two elements: material and consciousness; that is why we elementarize the brain with two subsystems: the CNS and the consciousness system. And that is why we elementarize our thinking behavior with two elements: linear and nonlinear, and further elementarize linear with two elements: divergent and convergent.

However, “elementarization” can also be done with the procedural names of entities. That is why we elementarize the consciousness signals by three elements: memory, sub-consciousness, and subjective consciousness; that is why we elementarize intelligent system with four elements: intention, cognition, decision, and action; that is why we elementarize “intelligent information processing” with three elements: “concepts connections”, “new concept formation”, and “the improving and approving of the new concept”.

This “elementarization” process has turned a difficult research project into studying its different subsystems and their connections, which generally means a much easier work to do. We will see this process is vital to solve those “impossible” problems, such as the theory of consciousness, the *Theory of Everything* in physics, and how to develop the Strong AI.

1. “Perspectives” is one of the major options of “hierarchy”, and it means to study entities from different views to build up the hierarchical trees in three dimensions.

“Perspectives” basically means to study an entity about its structure, behavior, and running mechanism, because these are the three aspects to describe an issue. That is why we have arranged our study of the consciousness system to study its structure, behavior, and running mechanism. And the secondary way to see “perspectives” is to study an entity or its respects from different disciplines, such as physics, life science, psychology, etc.

As “non-absoluteness” refers to the wholeness of an entity, we see that the study of all entities shall follow three other concerns: “generality, alienation, and boundary conditions”. Let us explain them as below:

1. “Generality” is the basis for wholeness, and it means to focus on the primary goal of research project and ignoring all others.

“Generality” means to focus on the primary goal, and this implies to transform the primary goal of the research project into a couple of “yes or no” questions. For instance, in this research, we have been focusing on two questions: A. “if there is a CNS-independent consciousness system?”; B. “if memory, sub-consciousness, and subjective consciousness are just the three excitation forms of the consciousness signals”. This “yes or no” principle can turn a difficulty project (or question) much easier because it has unveiled the essence of project (or question). For instance, regarding the experimental design of examining consciousness, that is why we only aim at telling if the method to measure consciousness is right or wrong, in the first stage of the experiment.

1. “Alienation” is the basic practice to “generality”, and it means to identify those most unclear or obscure issues as the “elements” of an entity to identify all of its “elements”.

The “Alienation” practice means to stand away from the targeting entity to get a whole picture of it, and the “stand away” means not only in geometry but also in conception. For instance, when Newton saw an apple fell on the ground, he did not know that apple belongs to the earth or not, and he just considered it as another planet, then he had discovered the gravity law. And in this research, that is why we have assumed there is a CNS-independent consciousness system as long as there is no mature theory to say no; that is why we have assumed that consciousness is independent of neurons as long as there is not a mature theory of NCC (neural correlates of consciousness) to say no; this is why we have assumed that nature has a more fundamental impact behind force, as long as modern physics cannot say no.

1. “Boundary conditions” is the main practice to “generality”, and it means to examine the edges of an entity from all aspects.

Fixing the “Boundary conditions” is the main practice to answer a “yes or no” question, so it is the main practice to “generality” and the basis to learn anything. For instance, in this research, that is why we have kept focusing on telling the “boundary conditions” of linear thinking and nonlinear thinking in our thirty years study of consciousness.

The holistic view of nature:

We have gotten the holistic view of nature with the “general model of nature” from a three-layer hierarchical tree of nature as below, which we had discussed in the above introduction of the “general methodology of research”.

Nature

The CNS

Material

Life phenomena

Subjective consciousness

Consciousness

Conscious phenomena

Material phenomena

Human brain

The consciousness system

Memories

Sub-consciousness

Fig.3.1.5.2    The general model of nature

Let us emphasize and repeat as follows: first, life phenomenon is abstracted as the intersection of material and consciousness; second, human brain is chosen to be the focus of life science; the brain is assumed to have two subsystems: the CNS and the consciousness system, so brain science is being segmented into three theories: the theory of CNS, the theory of consciousness system, and the theory of their interaction (the theory of NCC); third, the consciousness system is assumed to produce the consciousness signals in three transformable groups, from low to high three excitation levels show as memory, sub-consciousness, and subjective consciousness.

* 1. The model system of nature

The model system of nature is vast and infinite, but we have been focusing on describing the role of consciousness to obtain the view of nature in its wholeness.

3.2.1      The physical model of nature

We assume that nature is composed of an unknown more fundamental element (MFE), and the GIN is the impact of the MFE. So, the coupling impact between the MFEs is under two types of singularities. Type one is called the singularity of contradiction (SC) because the impact on the MFEs is reversed suddenly; type two is called the singularity of transformation (ST) because the impact on the MFEs is amplified/attenuated suddenly to make the MFEs show senior properties. And the STs are in two groups, group A (STA) makes the MFEs show as the “material” world, such as atoms, neurons, the universe, etc; group B (STB) makes the MFEs show as the mental world, such as the consciousness system, memory, emotion, etc. So, the conscious impact is a different senior impact also in coupling state, but beyond modern physics. As those singularities exist in the full range of each unknown fundamental physical quantity, they have quite some intersections with each other. So, we could extend this MFE model to give a novel scenario of nature as below:

a)    Around the cross-points of SC and STA, the impact suddenly reverses. For instance, the gravity force between two objects will be turned into a repulsive force of the same strength suddenly in case their distance reaches new levels.

b)    Around the cross-points of SC and STB, the mental impact suddenly reverses. For instance, the interest or attraction to any object can suddenly be turned into boredom in some conditions.

c)    Around the cross-points of STA and STB, the MFEs show the properties of the atoms and the consciousness system harmoniously and simultaneously—that is exactly what the life phenomena are. So, those cross-points are called the singularity of life, and each singularity stands for one species.

In summary, we have used the MFE and its coupling GIN impact to build up this physical model of nature, which is the physics-version of Neutral Monism.

3.2.2      The physical model of the brain

3.2.2.1 The four types of signals in mental processes

We have identified four types of signals during mental processes, so we could develop the model system of nature finer.

① Consciousness signals (CS) are the outcome of the consciousness system that gives us conscious experience.

② Neuronal signals (NS) refer to neural activities, which include both inside and outside of neurons, either in one neuron cell or in a group, both electrical and biochemical, and spatially both local and global in the brain.

③ Stimulus signals (SS) refer to the physical stimulus to our body, from both outside the body and inside which are generated by the body itself. And its forms vary from light, sound, and smell, to electricity, temperature, pressure, and so on.

④ Psychological signals (PS) refer to what we feel, behave, and observe. And its forms vary from expression, and talk, to emotion, body language, etc. What we felt about ourselves is the only direct way and the most precise “technology” to measure the content of consciousness till now.

3.2.2.2 Human brain is in two subsystems: the CNS and the consciousness system

The brain has two subsystems: the CNS and the consciousness system, and human mental processes are the outcomes of their running and interactions. So, brain science is in three theories. The two theories of its two subsystems, and the third theory about their interaction, and we have the basic assumptions about them as below:

1. The running laws of the CNS are identical among people because the general structure of the brain is identical. This is based on anatomy and other empirical knowledge in neuroscience.
2. The running laws of the consciousness system are quite varied among people because the structures of their consciousness systems are quite varied. This is from that peoples’ personalities are vastly varied. We see that peoples’ kinds of consciousness systems have determined their patterns of thinking, and their patterns of thinking are observed as their personalities. Physically, the consciousness system is also beyond force, space, and mass, and its exact property is based on one type of singularity of the MFE.
3. The interacting law between the two subsystems is also known as the law of NCC (neural correlates of consciousness), and people cannot have identical interacting laws unless they are in the same kinds of consciousness systems. Physically, their interactions are beyond space and most other physical variables because the consciousness system is beyond space and most other physical variables, so their interaction is paralleled in the whole-brain space, instead of overlapping to some fixed area of the CNS. But, on the other hand, their interactions are related to space and most other physical variables because neurons are related to them. Physically, as both subsystems are from the MFEs, their interaction can affect not only both their signals but also both their structures if the interaction is strong enough, which generally implies mental diseases of neuronal or psychopathic respectively.

3.2.3      The physical model of the consciousness system

3.2.3.1 Define consciousness and its four aspects

**Consciousness** is the opposite of material and its three excitation levels show as memory, subconsciousness, and subjective consciousness. Let us describe consciousness further with its four aspects, so we can specify the model system of nature finer.

**Conscious phenomenon**: The initiative activities of an entity to show its existence, especially the activities to avoid its end (death) or having a new start (reproduction). This a little weird definition is based on our observation of living creatures, and it is to distinguish conscious phenomena from the sensory activities, either it is neural or mechanical, or computed. But this definition is not binding consciousness to the current living creatures, instead, it has implied that any entity that can give conscious phenomenon shall be treated as life even if it would be a manmade one.

**The consciousness system**: The derived form of the MFEs that gives off the consciousness signals.

**The consciousness signal**: It is the outcome of consciousness system performance, and it works with neural signals to produce human mental processes. Literally, each piece of our memory, idea, and other forms of knowledge in the mind can be considered as one consciousness signal, no matter we feel it or not. Physically, though its detailed properties are unknown yet, it is in a senior coupling state beyond modern physics, say not electromagnetic, biochemical, or neuronal.

**Our conscious experience**: Our conscious experience refers to the psychological feeling that is based on the group work of consciousness signals. And this definition is to emphasize that the unfelt sub-consciousness signals have always joined the group work and be part of our mental processes, and that is why we see that intuition and instinct are always part of the mental processes.

3.2.3.2 The four physical aspects of the consciousness system

**Its structure**:

The consciousness system is derived from the MFE, and both its body and its impact are in a novel coupling state, which is beyond space, mass, and force. That coupling is similar to its substrate (MFE), but in a developed senior form. Because of this coupling property, it is also named physically as Thinking-Coupling (TC). One TC is composed of millions of mini-TCs, and each of them corresponds to a unique consciousness signal with its unique coupling factor. And the content of a coupling factor refers to one piece of our ideas, memories, and thoughts. But one mini-TC is not indeed physically independent, rather only literally. This is because its coupling factor can be considered literally as a group of mini-coupling factors in quite a number, and one mini-coupling factor can either stand-alone or synergize with any other one from its own group or other groups to be a "new" mini-TC.

In the spatial view, as both the size and the running of the consciousness system are beyond space, mini-TCs are paralleling in space instead of overlapping, while the interactions are determined by the kinds and grades of their mini-coupling factors for their excitation intensity instead of a force in any form.

The groups of mini-TCs can be classified psychologically by the kinds of our ideas, concepts, or knowledge.

The general coupling pattern (GCP) of TC is determined by the coupling patterns both within all those groups themselves and between different groups. Peoples’ GCPs are innate and generally unchanged after their grown up. One’s experience and education can only affect the volume of each group, and that is why peoples’ kinds of consciousness systems are quite stable during their adulthood. Psychologically, we can understand the running of the consciousness system is under many kinds of operation factors, and they behave differently psychologically. Peoples’ grades and quality references of their operation factors have determined their kinds of consciousness systems, just as they have determined their personality and intelligence quality.

**Its signal:**

The consciousness signals always couple at three levels, that psychologically behave as memory, sub-consciousness, and subjective consciousness. This is like the water molecules shown in three forms as ice, water, and steam.

Memory

Sub-consciousness

Subjective consciousness

**Low threshold**

**High Threshold**

Fig.3.2.3.2.   The three excitation levels of the consciousness signals

As **Fig.3.2.3.2** shows, the two coupling thresholds of mini-TCs have given the three excitation levels of the consciousness signals as below:

1. Below the low threshold, consciousness signals are at their non-excited state. They are the stable memories, the storage form of information.
2. Above the low threshold but below the high one, consciousness signals are at their low excited state. They are sub-consciousness that is not stable and can interact with other active consciousness signals. Btw, the low coupling intensity does not necessarily mean a lower chance to couple with others because the coupling chance depends more on the content of its coupling factor instead of its coupling intensity.
3. Above the high threshold, consciousness signals are at their high excited state which is the only state that people can feel. They are the subjective consciousness that is very unstable and highly active to interact. Btw, the high coupling intensity does not necessarily mean a better chance to couple with others because the coupling chance depends more on the content of its coupling factor instead of its coupling intensity.

Same as other forms of physical excitations, the coupling intensity drops more swiftly at the higher levels. So, the subjective consciousness signals are in much fewer counts than the sub-consciousness signals, and the main body of human mental processes is run by the sub-consciousness signals.

The couplings of mini-TCs are determined by the content of their coupling factors and something else called as “intention”.

**Our conscious experience:**

Conscious experience is based on the integrity of millions of consciousness signals, both active and inactive, though it is a psychological concept.

The groups of consciousness signals from mini-TCs can be modeled psychologically as below:

1. One’s consciousness signals are in a hierarchical group system according to his knowledge, and the basic model of humanity is classical:

① basic concepts of life and environment, such as life, death, action, movement, nature, etc;

② more sophisticated concepts in physical and spiritual including family, gender, emotion, culture, philosophy, etc;

③ about study and education;

④ about the economy;

⑤ about art.

1. Neither one group’s position in this group system, nor one consciousness signal’s position in a group or in which group, is fixed, but in a highly shifting status under some principles. So, the signals can be connected very absurdly.

**Its power system:**

The physical state of a consciousness system is decided by both its structure and its power system, because the power system determines one TC’s general coupling intensity level. We cannot model this power system or its connection with the CNS, but luckily, we can model it later because participants’ power systems are considered running at the same level under our measuring method.

3.2.4 The behavioral model of the consciousness system

The behavioral model of the consciousness system is developed to understand its virtual structure. We have observed peoples’ behavior to classify human patterns of thinking (POT), then, model the consciousness system by several sets of operation factors that each corresponds to a distinctive behavioral trait. We have managed to quantify the operation factors’ grade and quality reference by the psychological specification. So, in the end, we could measure and label peoples’ kinds of consciousness systems psychologically with their operation factors’ grade and quality reference.

3.2.4.1 The linear operation factor in four elements

We notice that the linear behavioral trait is the basic character of all intelligent systems, so we choose the linear operation factor to be the primary operation factor to model consciousness systems metaphysically. We elementarize linear logic by two elements: linear and nonlinear, then, further elementarize the linear element by two sub-elements: divergent and convergent. So, we have four elements to describe the linear operation factor: “linear”, “nonlinear”, “divergent”, and “convergent”. Let us use the picture to distinguish them as below:

1. The “linear” element: reasoning from one concept to another with understandable logic.

A

A1

A2

  Fig.  3.2.4.1.1.      The “linear” element

1. The “nonlinear” element: reasoning from one concept to another without understandable logic.

A

D

Fig. 3.2.4.1.2    The “nonlinear” element

1. The “divergent” element: reasoning from one concept to several other concepts with understandable logic.

A

A12

A23

A3

Fig. 3.2.4.1.3   The “divergent” element

1. The “convergent” element: reasoning from several concepts to one concept with understandable logic.

A5

A4

A3

A2

Fig. 3.2.4.1.4    The “convergent” element

After defining these four elements, we can model the linear operation factor according to the linear behavior of human mental processes as below:

1. The linear element refers to the “straight” coupling pattern of the TC (Thinking-Coupling), which means to produce a new mini-TC with an existing paradigm; the nonlinear element refers to the “disperse” coupling pattern of TC, which means to produce a new mini-TC without an existing paradigm. And the divergent element refers to the diversity degree of paradigm that TC can follow; and the convergent element refers to the convergence degree of paradigm that TC can be.
2. We labeled the pattern of thinking (POT) as AxByCzDw, “ABCD” stands for the elements of “linear, nonlinear, divergent, and convergent” accordingly, and “xyzw” stands for their grades correspondingly. And the kind of consciousness system is labeled as “axbyczdw”. In fact, we have modeled all four elements in ten grades with a relevant psychological specification sheet. (Details of the sheet have been described elsewhere (Ref) to make this paper concise.)
3. You may notice that the grades of four elements are easy to measure psychologically, but their quality references are much harder to be measured. We have noticed that the divergent and convergent elements are secondary to the linear elements, and their grades can be used to describe the quality reference of not only the linear element, but also the nonlinear element, because the quality references of four elements are generally the same since they are from the same TC. So, we have used the grades of the divergent and convergent elements to stand for the quality reference of a consciousness system. So, “axbyczdw” is used to label the kind of consciousness system.
4. Physically, let us further specify the linear operation factor in four points: ① the four elements are all coupling based, so their principal property are all nonlinear, though three of them behaved linearly; ② the linear and nonlinear elements reflect in two different ways of coupling, though they are not opposite, but they do oppose each other to an extent, so this implies that only very few people could have high grades on both of them; ③ the divergent and convergent elements reflect two independent coupling steps, and they are not related to each other; ④ the nonlinear and divergent elements reflect two different physical conceptions, which has no connection with each other, though the nonlinear behaviors are considered only as a branched form of the divergent behaviors in modern psychology.
5. In the view of the linear thinking behaviors, ① the strong linear thinking and nonlinear thinking people should both have high grades of the divergent and convergent elements, otherwise, their quality of linear and nonlinear thinking cannot be “strong” to be always correct and meaningful; ② the strong linear thinking people should have a high grade of the linear element while a normal grade of the nonlinear element; ③ the strong nonlinear thinking people should have a high grade of the nonlinear element while still above the normal level of the linear element, otherwise, their nonlinear behavior cannot be strong enough to be always correct and meaningful; ④ very few people could have real high grades of the linear and nonlinear elements at the same time, because this generally implies a high rate of TC’s error which means mental diseases.
6. In a psychiatric view, the nonlinear element connects to mental diseases more directly than the linear element, because the “disperse” coupling can lead to TC’s error much more easier than the “straight” coupling.
7. We have chosen four groups of participants to do the experiments of measuring the consciousness signals. Two study-groups with healthy and unhealthy strong nonlinear thinking behavior, which kinds both labeled as “a7b7c8d8”; two reference-groups, which the kind of “a8b5c8d8” for the strong linear thinking people and the kind of “a6b5c6d6” for the normal thinking people. (The methods to distinguish the healthy and unhealthy nonlinear elements have been described elsewhere (Ref) to make this paper concise.)

3.2.4.2    Other operation factors

Other operation factors named by distinctive behavioral traits are as below:

1. Thinking with image or not.
2. The rank of the hard memory.
3. The rank of curiosity.
4. The rank of imagination.
5. Contradicted personalities are chosen to examine the opposite coupling patterns of the TC: Optimistic/pessimistic, idealistic/realistic, rational/irrational, austere/excessive, altruistic/selfish, etc.
6. Contradicted behavioral traits are chosen to examine the opposite coupling patterns of the TC: Extrovert/introvert, imperative/obedient, used to act promptly or hesitantly, comparative way or the absolute way in evaluations, etc.

3.2.4.3 Mental twin

Mental twins refer to people who have the same kinds of consciousness systems. They are like the same types of “thinking machines”. And they have the common grades and quality references on all their operation factors or some of them.

3.2.5      The running model of the consciousness system

We have developed the running model of the consciousness system to describe the mechanism of conscious processes from three perspectives: interacting with the CNS, processing the consciousness signals as a physical machine, and processing the information as a metaphysical intelligent system.

3.2.5.1 Interacting with the CNS

We have illustrated their interaction with the CNS by the flowchart of four consciousness-related signals as below:

Consciousness signal (CS)

Neural signal (NS)

Psychological signal (PS)

**Participant**

**CNS**

**Consciousness system**

**Physical stimulus signal**

Fig.3.2.5.1.      The signal flowchart of mental processes with stimulus

As we can see, there are four groups of neural signals (NSs): 1) the CNS-background NSs; 2) the behavior-resulting NSs; 3) the consciousness signal-coupling NSs; 4) the carrier NSs. Though they may overlap to an extent, we distinguish them theoretically for the experimental design. Please notice that, without physical stimulus from the outside or inside the body, our contemplation and meditation can ignite the NCC effect with the same composition.

And there are six groups of exciting consciousness signals (Excited CSs): 1) the existing central processing CSs; 2) the neural-ignited CSs; 3) the thinking-ignited CSs; 4) the memory-originated CSs; 5) the memory-producing CSs; 6) the behavior-resulting CSs. Though they may overlap to an extent, we distinguish them theoretically for the experimental design.

Please notice that the last three groups of the NS are related to the CS and combined to be the neural correlates of consciousness (NCC) effect. So, we emphasize as below:

1. The NCC effect is in three groups of NS;
2. The NCC effect has four conscious steps: ① preparing some new CSs; ② the central processing of the new mini-TC with new information; ③ storing the new information into memories; ④ behave with the new information via the CNS.
3. Only the central processing of the new mini-TC is the process of making new information, say the part of the NCC effect which connects to the content of the new information.
4. The physical stimulus signal produces identical NSs in people; the behavior-resulting NSs produce identical behaviors in people.

3.2.5.2 Processing the consciousness signals as a physical machine

We have developed a flowchart to indicate the steps and procedures of processing the consciousness signals (CS) to explain the mechanism of conscious processes.

1-new CSs from physical stimulus and contemplation

3- a new mini-TC forming from the central process of CSs

NSAxByCzDw(m,n,o,t)

6-new LTM from STM

2-new CSs from LTM

**Consciousness system: axbyczdw**

**POT: AxByCzDw**

7- a PS from the new concept

5-new CSs from STM from

4-new CSs as STM

PSAxByCzDw (t)

Brain

CSaxbyczdw(m,n,o,t)

**Fig.** 3.2.5.2**.**   The flowchart of the consciousness signals

The seven steps of processing the consciousness signals (CSs):

Step one: Producing new CSs with stimulus or just contemplation.

Step two: Producing new CSs from Long-term memory (LTM).

Step three: Producing a new mini-TC for the new concept1 by the central processing of CSs, and finalizing it in a cyclic process.

Step four: Producing new CSs as Short-term memory (STM) from the new concept1.

Step five: Producing new CSs from STM to join the central processing of CSs.

Step six: Producing new LTMs from the new STMs.

Step seven: Give off a new PS1 based on the finalized concept1 from the new CSs.

The eight procedures of processing the consciousness signals:

Procedure one: Producing the new CSs group A in processing step one.

Procedure two: Producing the CSs group B in step two.

Procedure three: Producing the premature new concept1 in CS form in step three by processing the existing CSs, group A, and group B.

Procedure four: Producing the CSs group C from that premature new concept1 as the STMs in step four.

Procedure five: Producing the CSs group D to join the central process in step five.

Procedure six: Repeating procedures one to five several times to produce the final new concept1 in CSs group E with the final decision.

Procedure seven: Producing the PS1from the CSs group E in step seven.

Procedure eight: Producing the new LTMs from the CSs group E in step six via the STM stage.

Please notice that concept2 might not be exactly concept1, and concept3 might not be exactly concept2 during the cognitive processes.

3.2.5.3 Processing the information as a metaphysical intelligent system

To understand the “conscious information processing”, we have virtually considered the consciousness system as an intelligent system. We have firstly defined intelligence and many of its related concepts, then modeled the “conscious information processing” out later.

3.2.5.3.1 Intelligence and its related concepts:

*Information* is what describes things, which has its formations in two levels. *The basic level* is the within-domain concepts, which are generally in material, such as pictures, articles, and computer code. Those pieces of information are generally fixed and not flexible because they are in the material. *The* *high level* is the beyond-domain concepts, which are the different variations from the same hierarchical structure of the UKEs (universal knowledge elements). Those pieces of information are highly shiftable, because either the different views of the same structure or the little variations of a structure may give off completely different concepts. As the within-domain concepts can never fully describe a beyond-domain concept, no matter how many, that is why “*the high-level formation of information*” is required to be conceptualized.

*Intelligence* is a system, either physical or virtual, that could process information in four procedures: intention, cognition, decision, and action.

*Narrow intelligence* can only process the basic-level information, say with a fixed domain. So, it has only the incomplete-cognition which cannot give off GKR (general knowledge of reality), especially not knowing itself.

*General intelligence* can process high-level information, say beyond domains. So, it has the complete-cognition which can give off the GKR, including knowing itself. We see that the high-level formation is non-absolute, and it matches the non-absoluteness of reality much better than the fixed basic-level information. The current AI cannot process high-level information, and it is not a general intelligence.

*The Strong AI* is the general intelligence that has even better quality and capacity than humanity.

*The* *specification of intelligence* is described with the “dynamic” and “static” two factors. A) the dynamic factor is detailed in three “elements”: ① Ignite the existing information; ② Produce new information; ③ Store new information;

B) the static factor is detailed with the volume and the quality of knowledge, and in two viewpoints as: ① The general knowledge, such as nature of reality, philosophy, art, and civilization; ② The specified knowledge, such as neuroscience, the art of family life, etc.

*The three procedures of processing information:* ① Connecting the existing information; ② Forming a piece of new information; ③ Improving and approving of that new information.

We see the “specification and procedure” concerns are critical in developing the Strong AI.

3.2.5.3.2 Conscious information processing

The “conscious information processing” is special with its three essential points or “elements”:

1. With a “self-controlled intention”;
2. Processing the high-level information to achieve the GKR;
3. Properly following the “principle of cognition”.

We see that the humans and all other living creatures have the “conscious information processing” because they all live with these three points, though their “specifications of intelligence” are vastly varied. Please kindly notice that the “consciousness”, the “concepts in mind and beyond domains”, and the “self-controlled intention” sounds to be three attached physiological concepts, but they are here three independent concepts in cognitive science.

3.3 The method to measure the consciousness signals in the lab

The method is to measure out the “real” NCC data that matches a piece of consciousness, and it is to filtrate out the “noise” neural signals by comparing the two paralleled conscious processes of the common information between mental twins (people with the same kinds of consciousness systems). The two steps are as below:

1. Prepare four participant groups that have corresponding mini-groups of mental twins. Psychologically measure peoples’ patterns of thinking to build four groups, each with 15 persons. The two study-groups are the healthy nonlinear thinking people and the unhealthy nonlinear thinking people; the two reference-groups are the strong linear thinking people and normal people. Then, further measure their other operation factors to build up 4 corresponding mini-groups, each with 3-5 mental twins.
2. Producing the paralleled “Consciousness information processes” in mental twins. Measure with EEG equipment, and record only their common data as the “real” NCC for the content of that piece of information. As far as the “common data for one piece of information” has its similarity to an extent at different times and the “common data for that piece of information between different mental twin groups” can be distinguished clearly and repeatedly, the method will be approved.

Further details of this method have been described elsewhere (Ref).

Regarding the measuring method, please notice that ① fMRI, MEG, or any other technique of measuring neural signals can do the same work, though EEG results may reflect the NCC most directly; ② An experienced psychological measure of peoples’ patterns of thinking is vital because only the precise enough mental twins can make the “filtration” meaningful; ③ Choose a right piece of information to measure is also important, because only the right match between the information and the target operation factor can produce the distinct enough NCC effect; ④ The NCC measurement can only target subjective consciousness because participants cannot report their sub-consciousness, but both the behavior measurement for the kinds of consciousness systems and the measurement of the neural signals for the NCC have included the work of sub-consciousness because both their behaviors and NCC are affected by their sub-consciousness though they had not felt them. And this shall be concerned in the experiment to avoid possible major mistakes.

Regarding the “data filtration”, it needs to be done from two aspects as below:

1. Filtrate the NSs (neural signals) by their identities in three groups: the background NSs of the brain, the carrier NSs in NCC, and the exceptional NCC to a piece of consciousness signal.
2. Filtrate the exceptional NCC by three procedures in conscious processing: the input, the output, and the central process. And only choose the part of the central process as the targeted “real” NCC data.

Regarding the “quality of measurement”, it can be judged at two levels:

1. The primary requirement is the “real” NCC can be independent of its input options (by watching or listening) and its output options (telling out something or not).
2. The high requirement is the “real” NCC can be distinguished from objects’ secondary characters, such as the “real” NCC of apple can be independent of their color and their number.

Regarding further experiments in case the method can be approved, the experiments will be organized at two levels as below, to study the property of coupling in both levels at the consciousness system and the MFE:

1. The basic level is to study the operation factors by comparing their kinds or their grades, with the common consciousness signals.
2. The senior level is to study the operation factors by using different consciousness signals.

However, we know that the different “measuring technologies” are always the basic option to study the operation factors, because EEG, fMRI, and MEG are having far different physical implications. And the key to successfully exploring the property of coupling is to figure out the boundary conditions between which mental behaviors, in our case, are “the difference between linear and nonlinear” and “the difference between healthy nonlinear or unhealthy nonlinear” good enough?

1. **Discussions**

4.1 The theory of consciousness is developed in physics and biology

This model system of nature is about consciousness from all aspects. The MFE’s coupling had explained not only the origin of consciousness, but also the coupling property of the consciousness system. The physical model of the brain had not only assumed a CNS independent consciousness system, but also split the Hard Problem of consciousness of Dr. David Chalmers into two theories: the “theory of NCC” and the “theory of consciousness system”. We have used the concept map of the Coupling Theory of Consciousness as supplementary material for this paper to give a more comprehensible explanation. And let us apply this model system to explain three conscious experiences as below (We are fully aware that if any type of conscious experience has logic-contradiction with this model system, then, this model should be a wrong one.):

1. The difference between linear thinking and nonlinear thinking

The difference is physically explained with the “straight” and “disperse” coupling ways of the TC. In the signal and information processing view, nonlinear thinking people can store much more conclusions between the memories and sub-consciousness states, those pieces of information can be easily recalled and participate in further information processing. They themselves do not feel this process either because it is subconscious, that is why their reasoning appears to be very nonlogical with all the steps-jumping in their thinking processes.

1. Hard memory and human creativity

Hard memory is to learn things with a reference. This refers to the “straight” coupling with the existing paradigm which shows as the linear element. That is why strong linear thinking people always have an excellent hard memory. From an intelligence view, hard memory is to couple out a new mini-TC according to an existing pattern, and it is a kind of copy work. However, coupling-out new mini-TCs from existing unrelated mini-TCs is a “disperse” coupling without the existing paradigm, and it means developing new coupling patterns without reference models, which implies a more innovative work, such as what imagination and inspiration do. The “straight” coupling and “disperse” coupling, these two mechanisms may refer to the two perspectives of human intelligence: the accumulation of knowledge and creativity. We see that these two mechanisms do not against each other directly, but they do decline each other to an extent. And this has matched our observation quite well. Some people with excellent hard memory are not so vivid at developing fancy new ideas; some fancy people have a poor hard memory.

1. Emotion and personality

Emotion is the group coupling of mini-TCs instead of the coupling between individual mini-TCs, and that is why emotions are usually general instead of acute. The group involved couplings are in several forms: one group itself; between different groups; between a group and an individual mini-TC. This coupling model has explained why the same issue can always produce the same emotion and why one emotion can always recall the same memory in life.

Personality refers to the GCP of the TC, or the hierarchical structure of people’s mini-TC groups. That is why emotions are always personality-based, and why adults’ personality is generally quite stable in their lifetime.

4.2  What the Strong AI is and how to upgrade current AI

The “conscious information processing model” has explained that the Strong AI should have three “elements”: a self-controlled intention, processing the high-level information, and the mechanism to well follow the six points of the “principle of cognition”.

We may develop the conscious-alike AI technology and upgrade current AI by developing a “universal knowledge elements” system, which is similar to but stronger than human language, so as to “compute” concepts under the GKR (General Knowledge of Reality) and beyond domains.

4.3 Why measure consciousness and why this method

Thinkers and researchers all know that if we could measure the content of consciousness, it will only be procedural to integrate all current theories into one. In our case, we will be able to test the model system of nature from all aspects and complete all related theories.

So, is our method meaningful and with advantages? Let us check two points below:

1. The method is purely logic-based and independent of any theory including our own theory, because how to filtrate out the “noise” signals and get the “real” NCC data is purely logical reasoning.
2. It has much lower requirements regarding measuring technology. It is generally an ID test instead of a quantitative test. It is to distinguish the kinds or the grades of the operation factors of consciousness systems instead of measuring the shifting content of consciousness signals.

We have noticed that Dr. Marcel Just and his team at Carnegie Mellon University have been proceeding with a very similar experiment to measure the consciousness signals, and what we suggest here is only a new method to filtrate out the “noise” neural signals.

4.4   Science is challenged from the bottom

Nature’s “non-absoluteness” has challenged the bottom of science in all disciplines. In physics, the non-absolute “vibration beyond space and force” GIN (General Impact of Nature) has challenged “force”, say the absolute “point-to-point basic impact” in modern physics. And the “boundary condition principle” is questioning the gravity law—the foundation of cosmology. In life science, the MFE model has challenged molecule-based life science and biology with its “coupling singularities’ intersection” model for the essence of life. And the consciousness system is challenging brain science and neuroscience. In cognitive science, the “principle of cognition” in six elements is trying to form its theoretical basis. In information science and computer science, the conceptions of the high-level information, the beyond-domain concepts, complete-cognition, GKR (general knowledge of reality), and self-controlled intention are trying to advance their theoretical basis.

4.5 Nature and science are summarized

We have summarized nature and science in only two words: “logicality” and “non-absoluteness”. This is pure science, though sounds philosophically.

These two words have united all knowledge of nature, even those things we do not know yet. “Logicality” turns nature into a hierarchy system in many many points, and all those points have their clear definitions and their relationships; “non-absoluteness” says that this hierarchy system is a high-shiftable one. It is shiftable because both the definition of each point and its connections with other points are having their boundary conditions while those conditions have their own ranges too. So, the hierarchy structure is highly flexible on each point, or on different conditions.

This intrinsicality of nature has also unveiled an ultimate truth of nature: “The rank of an entity in its type depends more on its flexibility (non-absoluteness) level NOT its structure (logicality) level”. And this emphasizes again that the Strong AI technology will count more on the new flexibility level of the information’s formation for a new flexibility level of processing information, NOT the information’s volume or processing speed.

Science is about not only logical but also nonlogical (non-absolute). We should review all existing theories and laws regarding their boundary conditions, and this is for both to double-check their completions and to discover new theories.

Mathematics in numbers is a powerful man-made tool of science, which also reveals nature’s laws profoundly. But it is not a branch of science in itself, because numbers are conceptualized to be absolute.

The “general methodology of research” has given the methodology of studying consciousness.

1. **Conclusions**

We had discussed five points in this paper. However, the first two are just suggested answers, and only the last three are for sure. ① The Coupling Theory of Consciousness; ② The three keys of the Strong AI and how to develop the conscious-alike AI technology; ③ The method to measure the consciousness signals; ④ Science is challenged from the bottom; ⑤ Nature and science are summarized and the methodology of studying consciousness is theorized.

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Conflict of Interests

We declare no conflict of interests.

References

Baars, B.J., *Global workspace theory of consciousness: toward a cognitive neuroscience of human experience.* Progress in brain research, 2005. **150**: p. 45-53.

Baars, B.J., *The global workspace theory of consciousness.* The Blackwell companion to consciousness, 2007: p. 236-246.

Baars, B.J. and S. Franklin, *Consciousness is computational: The LIDA model of global workspace theory.* International Journal of Machine Consciousness, 2009. **1**(01): p. 23-32.

Bayne T., Hohwy J., Owen A. M. (2016). Are there levels of consciousness? *Trends Cogn. Sci*. 20, 405–413. 10.1016/j.tics.2016.03.009

Bechtel W., Mundale J. (1999). Multiple realizability revisited: Linking cognitive and neural states. *Philos. Sci*. 66, 175–207. 10.1086/392683

Chalmers, D. J. (1996). The Conscious Mind: In Search of a Fundamental Theory. New York, NY: Oxford University Press.

Cosmelli D, David O, Lachaux JP, Martinerie J, Garnero L, Renault B, Varela F: Waves of consciousness: ongoing cortical patterns during binocular rivalry. *Neuroimage* 2004, 23(1):128-140.

Crick F, Koch C: A framework for consciousness. *Nat Neurosci* 2003, 6(2):119-126.

Crick F, Koch C: Are we aware of neural activity in primary visual cortex? *Nature* 1995, 375(6527):121-123.

Damasio, A. (2003) The feeling of knowing. Basic Books, New York.

David Bohm. (1980) Wholeness and the implicate order.

Dehaene, S. (2014). Consciousness and the Brain: Deciphering How the Brain Codes Our Thoughts. London: Penguin.

Dehaene S., Changeux J.-P. (2011). Experimental and theoretical approaches to conscious processing. *Neuron* 70, 200–227. 10.1016/j.neuron.2011.03.018

Dehaene S., Lau H., Kouider S. (2017). What is consciousness, and could machines have it? *Science* 358, 486–492. 10.1126/science.aan8871

Demarin, V. and S. MOROVIĆ, *Neuroplasticity.* Periodicum biologorum, 2014. **116**(2): p. 209-211.

Dexter, J.P., S. Prabakaran, and J. Gunawardena, *A complex hierarchy of avoidance behaviors in a single-cell eukaryote.* Current Biology, 2019. **29**(24): p. 4323-4329. e2.

Edelman GM: The remembered present: A biological theory of consciousness. New York, NY, US: BasicBooks, Inc; 1989.

Engel AK, Fries P, Singer W: Dynamic predictions: oscillations and synchrony in top-down processing. *Nat Rev Neurosci* 2001, 2(10):704-716.

|  |  |  |
| --- | --- | --- |
| Ernst Mach. [1890] | “The Analysis of Sensations—Antimetaphysical.” *Monist*, 1: 48. | |
| Ernst Mach. 1891]“Some Questions of Psycho-Physics.” *Monist*, 1: 394–400. | |  |

|  |
| --- |
| ErnstMach.[1892]“Facts and Mental Symbols.” *Monist*, 2: 198. |

|  |
| --- |
| Ernst Mach.[1906]“On Physiological, as Distinguished from Geometrical Space.” *Monist*, 11: 321. |

Faisal A. A., Selen L. P., Wolpert D. M. (2008). Noise in the nervous system. *Nat. Rev. Neurosci*. 9:292. 10.1038/nrn2258

Fanelli, D. (2019). A theory and methodology to quantify knowledge. R. Soc. Open Sci. 6:181055. doi: 10.1098/rsos.181055

Freeman, W. J., and Vitiello, G. (2006). Nonlinear brain dynamics and manybody field dynamics. Electromagn. Biol. Med. 24, 233–241. doi: 10.1080/ 15368370500379608

Fries, P. (2005). A mechanism for cognitive dynamics: neuronal communication through neuronal coherence. Trends Cogn. Sci. 9, 474–480. doi: 10.1016/j.tics. 2005.08.011

Fries, P. (2015). Rhythms for cognition: communication through coherence. Neuron 88, 220–235. doi: 10.1016/j.neuron.2015.09.034

Goff, P. (2017). Consciousness and Fundamental Reality. Oxford: Oxford University Press.

Grossberg, S. (2017). Towards solving the hard problem of consciousness: the varieties of brain resonances and the conscious experiences that they support. Neural Networks 87, 38–95. doi: 10.1016/j.neunet.2016.11.003

Hameroff, S., and Penrose, R. (2014). Consciousness in the universe: a review of the

‘Orch OR’ theory. Phys. Life Rev. 11, 39–78.

Han, W., et al., *Genetic influences on creativity: an exploration of convergent and divergent thinking.* PeerJ, 2018. **6**: p. e5403.

Hoel E. P. (2018). *Agent Above, Atom Below: How Agents Causally Emerge from Their Underlying Microphysics*. Cham: Springer International Publishing; 10.1007/978-3-319-75726-1\_6

Hohwy J. (2013). *The Predictive Mind*. Oxford: Oxford University Press; 10.1093/acprof:oso/9780199682737.001.0001

Hofstadter D R . Gdel, Escher, Bach : an eternal golden braid[M]. Vintage Books, 1980.

Humphrey N. (1999). *A History of the Mind: Evolution and the Birth of Consciousness*. London: Springer Science & Business Media.

Humphrey N. K. (1970). What the frog's eye tells the monkey's brain. *Brain Behav. Evol*. 3, 324–337. 10.1159/000125480

Hunt, T. (2011). Kicking the psychophysical laws into gear a new approach to the

combination problem. J. Conscious. Stud. 18, 11–12.

Hunt, T. and J.W. Schooler, *The easy part of the hard problem: a resonance theory of consciousness.* Frontiers in human neuroscience, 2019. **13**: p. 378.

James, W. (1890). *The Principles of Psychology*. New York: Henry Holt and Company.

John, E. R. (2001). A field theory of consciousness. Conscious. Cogn. 10, 184–213.

doi: 10.1006/ccog.2001.0508

Kandel, E.R., et al., *Principles of neural science*. Vol. 4. 2000: McGraw-hill New York.

Kanai R., Chang A., Yu Y., de Abril I. M., Biehl M., Guttenberg N. (2019). Information generation as a functional basis of consciousness. 10.31219/osf.io/7ywjh

Kent L ,  Wittmann M . Special Issue: Consciousness science and its theories Time consciousness: the missing link in theories of consciousness[J]. Neuroscience of Consciousness, 2021, 2021(1).

Koch, C. (2004). The Quest for Consciousness: A Neurobiological Approach. Boston, MA: Roberts Publishers (accessed March, 2019).

Koch, C. (2014). Is Consciousness Universal? Available at: https://www. scientificamerican.com/article/is-consciousness-universal/Lambert, N., Chen, Y. N., Cheng, Y. C., Li, C. M., Chen, G. Y., and Nori, F. (2013). Quantum biology. Nat. Phys. 9, 10–18.

Kolb B, Whishaw IQ: *Fundamentals of human neuropsychology* 4th edition. New York, NY: WH. Freeman; 1996.

Lamme V. A. (2006). Towards a true neural stance on consciousness. *Trends Cogn. Sci*. 10, 494–501. 10.1016/j.tics.2006.09.001

Lemon R., Edgley S. (2010). Life without a cerebellum. *Brain* 133, 652–654. 10.1093/brain/awq030

Mandrick K, Chua Z, Causse M, Perrey S, Dehais F. Why a Comprehensive Understanding of Mental Workload through the Measurement of Neurovascular Coupling Is a Key Issue for Neuroergonomics?. *Front Hum Neurosci*. 2016;10:250. Published 2016 May 31. doi:10.3389/fnhum.2016.00250

Nagel T. (1974). What is it like to be a bat? *Philos. Rev*. 83, 435–450. 10.2307/2183914

Nagel T: What is the mind-body problem? *Ciba Foundation Symposium* 1993, 174:1-7. discussion 7–13

Nagel, T., *Mind and cosmos: why the materialist neo-Darwinian conception of nature is almost certainly false*. 2012: Oxford University Press.

Newell, A. (1994) Unified theories of cognition: The William James lectures. Harvard University Press, Cambridge, MA.

Pennartz C. M. (2018). Consciousness, representation, action: the importance of being goal-directed. *Trends Cogn. Sci*. 22, 137–153. 10.1016/j.tics.2017.10.006

Penrose, R. and N.D. Mermin, *The emperor’s new mind: Concerning computers, minds, and the laws of physics.* American Journal of Physics, 1990. **58**(12): p. 1214-1216.

Price H., Corry R. (2007). *Causation, Physics, and the Constitution of Reality: Russell's Republic Revisited*. Oxford: Oxford University Press.

Raymont P., Brook A. (2006). Unity of consciousness, in *The Oxford Handbook of Philosophy of Mind*, eds Beckermann A., McLaughlin B. P. (Oxford: Oxford University Press; ), 565–577.

Rees, G., Wojciulik, E., Clarke, K., Husain, M., Frith, C. and Driver, J. (2002) Neural correlates of conscious and unconscious vision in parietal extinction. Neurocase, 8(5): 387–393.

Revonsuo A. (2006). *Inner Presence: Consciousness as a Biological Phenomenon*. Cambridge, MA: MIT Press.

Rosen R. (1991). *Life Itself: A Comprehensive Inquiry into the Nature, Origin, and Fabrication of Life*. New York, NY: Columbia University Press.

Schrödinger, E., *What is life?: With mind and matter and autobiographical sketches*. 1992: Cambridge University Press.

Skrbina, D. (2005). Panpsychism in the West. Cambridge, MA: MIT Press.

Steinke, G. K., and Galán, R. F. (2011). Brain rhythms reveal a hierarchical network organization. PLoS Comput. Biol. 7:e1002207. doi: 10.1371/journal. pcbi.1002207

Steriade M: Synchronized activities of coupled oscillators in the cerebral cortex and thalamus at different levels of vigilance. *Cerebral Cortex* 1997, 7(6):583-604.

Tononi, G., *An information integration theory of consciousness.* BMC neuroscience, 2004. **5**(1): p. 1-22.

Umberto Olcese, *The Role of Top-Down Modulation in Shaping Sensory Processing Across Brain States: Implications for Consciousness.* Front. Syst. Neurosci., 24 July 2019

Van Lommel, P., *About the continuity of our consciousness.* Brain death and disorders of consciousness, 2004: p. 115-132.

Vimal R . Towards a Theory of Everything: Unification of Consciousness with Fundamental Forces in Theories of Physics[J]. Vision Research Institute Living Vision & Consciousness Research, 2009.

Zhong, N., et al., *Brain informatics-based big data and the wisdom web of things.* IEEE Intelligent Systems, 2015. 30(5): p. 2-7.