A reductionistic and physicalistic understanding concerning consciousness

An explanatory framework

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Abstract

This article brings a new perspective on understanding consciousness, and it is an attempt to establish a reductionistic and physicalistic explanatory framework. It strives from two directions: (1) By studying the features of consciousness, we can formulate a theoretical model for consciousness. (2) Consciousness is existence, therefore, by asking what is existence in the physical world, we can distinguish three kinds of existence, by excluding the less feasible two of these three kinds, we can narrow the scope of research and focus on one of them. By figuring out the possible physical foundation, we can establish a concrete model to match the features of the theoretical model of consciousness. Base on this model, many phenomena can also be explained, such as, who or what am “I” (the self), why there is “something it is like”, What is the difference between conscious and unconscious, why digital computer cannot be conscious, etc.

Keywords:

conscious experience, the hard problem, existence, causal connection, physical foundation, reductionism, physicalism, binding problem

1. Introduction

Consciousness is a polysemous term, it can refer to the phenomenon of consciousness, but the most common meaning is conscious experiences, and when it is the meaning of conscious experiences, it must always refer to someone’s conscious experiences. Other terms such as “qualia” (singular form “quale”), “something it is like ¹”, also refer to conscious experiences. Conscious experience such as the redness of red, the painfulness of pain, the feeling of love, and so on, is everything presents in someone’s individual subjective world. These subjective things seem to be totally different from those objective things. Therefore, it is thought that there is an explanatory or epistemic gap^{2,3} between subjective and objective phenomena, and the problem of consciousness is called “the hard problem⁴”. This article is an attempt to narrow the gap. Consequently, efforts are made in two directions, one is from the “subjective”

side, by studying the features of consciousness, establish a theoretical model which regardless of its physical foundation, the other is from the “objective” side, to figure out the possible physical foundation of consciousness.

The ideas of this article are a version of reductive physicalism which contains two aspects, one is that consciousness can be reduced to simple components. The second is that the components that make up consciousness are physical, interactions between components obey physical laws. But “no one has produced any plausible explanation ⁵”, the hard problem remains unsolved. Some people think that it needs to be explained by quantum theory, and some others think that we need new physical laws to explain the phenomenon of consciousness. This article insists that it is not due to the physical laws have been discovered so far are not enough, but is due to there are no appropriate concepts. Consequently, I would take the concepts which are concrete enough to capture their approximate nature, not the concepts which are also need to be explained.

2. The features of consciousness

Consciousness has many features, in this article, I focus on several features that are essential for building a theoretical model for consciousness.

Feature 1: Consciousness is existence. Since “I think therefore I am ⁶” had been put forward, consciousness as existence has rarely been doubted. We can take this notion as a self-evident truth. Base on this notion, we can propose a roughest abstract model for consciousness: consciousness is existence. The word “abstract” means that we can temporarily ignore what kind of existence it is, whatever it is matter or other kind of physical phenomena.

Feature 2: Consciousness is composite. At any moment, someone’s consciousness is composed of many different experiences. For example, at any moment, consciousness can be composed of visual, auditory, olfactory experiences etc. Not only that, a visual sight can be composed of different colors and shapes, a sound can be composed of different voices, etc. Consequently, we can infer that, at any moment, consciousness is composed of many basic experiences, which are indecomposable, so we can call them *atomic experiences*. For example, a little dot in our visual field may be an atomic experience. The term atomic experience is different from the term “quale”, for example, suppose there are two little red dots in our visual field, they have the same experience of redness, so they are the same quale, but they are in different location, so they are different atomic experiences. Since consciousness is existence, an atomic experience is also existence. Therefore, we can describe the model of consciousness more specifically: at any moment, consciousness is a set of atomic experiences.

Feature 3: Each atomic experience has a life cycle, that is, every atomic experience must go through the process from non-existence to existence, and then from existence to non-existence, the process is repeatable for many atomic experiences. For example, suppose the experience of redness is an atomic experience, it must start at a certain moment and end at another moment, and we can experience redness many times during our lifetime.

Feature 4: Consciousness is happening at the present time. This notion contains two aspects. First, at a certain moment, what we experience is something happening at that moment. Something that happened at different moments cannot be experienced at a certain moment. For example, suppose that a certain neuron firing in my brain is the experience of seeing red, then when I am seeing red, this neuron must be firing, and vice versa. It is impossible that

this neuron was firing a second ago, and it took me a second to experience redness. In another words, when I am experiencing something, there must be something existing(happening) right now. Second, we can only live in the present, not in the past or the future. When we recall the memory, something that happened before is happening again.

Consciousness that happens at a certain moment can be called *instantaneous consciousness*. When we are awake, consciousness flows like a river or a stream⁷, which can be regarded as a series of instantaneous consciousness arranged in chronological order, and it can be called *consciousness-stream*. Now we can update the model: instantaneous consciousness is a set of atomic experiences, consciousness-stream is a series of instantaneous consciousness, and is also a set of atomic experiences.

Feature 5: Consciousness is unified, and instantaneous consciousness and consciousness-stream can both be unified (as discussed later, instantaneous consciousness as a unity is only approximately true). But there are no consistent criteria for the term “unity” in science. “The idea of unity is multifaceted and has been understood in many different ways by different thinkers. ⁸” This article proposes an alternative for understanding “unity”. Suppose there is a set of elements, this set can be unified only if each element in this set has specific connection with other elements which are also in this set, and has no such connection with the components outside the set. The connection also limits the set to a certain range. For consciousness, an element is an atomic experience, so we can update the model of consciousness: instantaneous consciousness is a set of atomic experiences with a certain range, and each atomic experience within the set has connection with other atomic experiences within the set.

Feature 6: Every atomic experience has a unique qualitative feel to it, this feature is called “Qualitativeness”⁹ of consciousness. It is most mysterious, puzzling and difficult aspect of consciousness. Because of this feature, the problem of consciousness becomes the hard problem.

Although the qualitative of atomic experience looks very complicated, it can be understood as containing only two aspects. (1) Aspect of difference, that is, each atomic experience has a quality of “difference”, which make it different from any other atomic experience, and every atomic experience possesses the same quality of “difference”. For example, the atomic experience of seeing red is different from seeing blue, both of those are different from hearing middle C, and all of them are different from atomic experiences such as feeling of touch, pain, or love, etc., the difference between seeing red and seeing blue, is the same as difference between seeing green and feeling love. It can be inferred that the quality of difference has no magnitude, dimension or unit, just different. (2) Aspect of equivalence, that is, when an atomic experience occurs, it is feel like what it is, specific and definitive, and when it occurs again, it is equivalent to what it was.

Based on this view, we can gain a new perspective on understanding atomic experience. That is, different experiences can have the same nature, they all contain two aspects, which are difference and equivalence. Consequently, consciousness can be composed of many components which have the same nature. This conclusion does not seem very intuitive, that is, the components “look” the same (from an observer), but the experiences are different (from the self). This has some similarities with computer memory. Computer memory is composed of a series of units with the same physical structure, i.e. the same nature, but each unit has its own unique address (This

is an example to help understanding. Other than that, there is nothing in common between experiences and computer memory). This new perspective is slightly different from the traditional understanding. The way that computers represent color is a microcosm of the traditional understanding. Computers use different values to represent different colors. According to this traditional understanding, different experiences must “look” different from an observer, as opposed to the opinion of this article, which is different experiences “look” the same from an observer.

Feature 7: Different atomic experiences *can* have commonalities. For example, we can see two red dots in our visual field at the same time, they are different experiences because they are in different locations, but they have the same color, which is their commonality. Without this feature, according to the conclusion of feature 6, atomic experiences are different from each other, then experiences they compose will be meaningless like white noise, it seems to conflict with feature 6. Here, I propose a possible solution to this problem, that is, suppose there are two atomic experiences, namely A and B, if they have a commonality, then, they must be able to activate a common atomic experience, namely C, if they have another commonality, then, they must be able to activate another common atomic experience, namely D. This solution can explain why two atomic experiences can have commonalities and are compatible with the conclusion of feature 6. Not only that, when the atomic experiences activate their commonalities (common atomic experiences), they connect with each other and combine into a unity.

Feature 6 and 7 are the informatic features of consciousness. Base on them, we can formulate basic guidance on consciousness encoding, this guidance is also suitable for information theories and representation theories: (1) Any information such as conscious experiences, can be reduced to a certain number of indecomposable components, and can be represented by equal number of discrete elements. (2) For any two elements can have 0 to n ($n \geq 1$) commonalities. (3) If some elements have commonality, they must be able to activate a “new” element to represent this commonality.

By now, we can formulate a more explicit model of consciousness but left out the physical foundation which I will discuss in the following sections.

These features can easily remind us of neural networks in the brain. If an action potential is an atomic experience, then they will have a lot in common. For example, each action potential has a life cycle, and each of them has the similar physical structure, they are “highly stereotyped throughout the nervous system¹⁰”. “the information conveyed by an action potential is determined not by the form of the signal but by the pathway the signal travels in the brain.¹⁰” But this is not enough for us to be confident to assert that an action potential is an atomic experience, and we need to do some work on the other side of the explanatory gap.

3. Existence in physical world

Existence is a topic that is often discussed in philosophy. Physicists studied existence too, but it was somewhat different. For example, physicists cared about existence of ether, Higgs boson, graviton, etc. Whether they exist may be the final answer. When we study consciousness, whether it exist is only the starting point. We also want to know what kind of existence it is. What kinds of existence are there? It is a question neglected by physics. So, we need to clarify the concept of existence in physics. We can distinguish three types of existence from a perspective of classical

physics.

The first type of existence is matter. In classical physics, matter is any substance that occupies space and possesses rest mass. From the perspective of particle physics, matter is composed of atoms and anything made up of them. In the Standard Model of particle physics, matter is made up of matter particles—fermions.

The second type of existence is the interactions, also known as forces. All of the known forces can be classified into four fundamental interactions, the gravitational, electromagnetic, strong and weak interactions. Each of them can be described as a field, so we can use the term “field” to refer to the second type of existence. Fields are more common than matter in the universe. For example, the gravitational and electromagnetic fields, which produce significant long-range forces that occupy space, making that there is no room for the “true vacuum”.

For the third type of existence, there is no “ready-made” concept in physics to generalize it, although it is as common as matter and fields. There are many phenomena in nature, such as lightning, wind, sound waves, etc., their existence is undoubtable, but they cannot be classified into matter or fields. For example, lightning can be considered as electric current, that is, the movement of charged particles under the action of an electric field. Although there are charged particles (matter) and electric field, besides them, there is also something else existing. For another example, the wind is the bulk movement of air molecules, when the wind stopped, the molecules that were involved in the movement still exist, but the wind doesn’t exist anymore. These phenomena involve energy, but energy is inappropriate for referring to the third type of existence. There are many types of energy, and they all fall into two basic categories: potential and kinetic energy. Potential energy can be classified into fields. Kinetic energy is also inappropriate for referring to the third type of existence, because kinetic energy is related to the motion of the object, and the motion of the object is related to the reference we choose, whether kinetic energy exists or not depends on the reference frame rather than the object itself. It is “observer-relative”. For example, suppose there is a high-speed train, relative to the passengers on the train, the speed of the train is 0, and the train has no kinetic energy, but for the observer on the ground, the train has great kinetic energy. As can be seen from the phenomena listed above, they all involve energy exchange (or doing work) and multiple objects, so we can use the term “energy-exchange” to refer to this type of existence.

For the following reasons, properties such as mass and charge, will not be considered as another independent type of existence: (1) Properties are the qualities presented by any type of existence such as matter. In addition to mass and charge, there many other properties that are not considered as existence. For example, volume is also a property presented by an object, but it is not considered as existence. And frequency of electromagnetic wave is another example. (2) If properties such as mass and charge are an independent type of existence, then any elementary particle would be seemed like a container that is storing various properties, the particle would be nothing left but “emperor’s new clothes”.

Likewise, there seems to be unknow forces that makes everything in the universe follow the same physical laws, such as law of gravitation. These unknow forces are not considered as an independent type of existence.

If all of the existence can be classified into the three types of existence, then consciousness should be composed

of one or several of the three. In this way, we can determine the research scope of the target through some methods, for example, use the exclusion method to find out what kind of existence consciousness cannot be. We can start from the first type: matter. If consciousness is matter, it means that they are composed of particles. This will bring a series of problems. Here are five, but not limited to these five.

- (1) Which length scale of things do the consciousness correspond to, and why?
- (2) Mapping(encoding) problem, that is, different experiences correspond to different substances, there must be a mapping relationship between subjective experiences and objective substances. How to explained this mapping problem?
- (3) Shifting problem. Metabolic processes are constantly taking place in the human body, the substances that make up the human body would be replaced. “Within about seven years every atom in your body will be replaced by other atoms. ¹¹” But consciousness stays with us. Consequently, experiences must be shifting from one substance to another, and how is that possible?
- (4) How to explained experiences have life cycle?
- (5) “Binding(Combination) problem^{8,12}”, how different objects are combined into a unity?

Base on the known physical laws, these problems would be really hard, tackling them seems to be “Mission Impossible”. These problems are almost the same for the situation that consciousness is some kind of fields, except the life cycle problem.

Because there are frustrating problems with matter and fields. On the other hand, the best candidate for neural correlate of consciousness—action potential, is mainly composed of electric current and chemical reactions, they are all energy-exchange, so we can easily conjecture that consciousness is the third type of existence—energy-exchange, and more specifically, consciousness is composed of many processes of energy-exchange. Next, we can examine the details of action potential, outline the physical foundation of atomic experience, and introduce a term: *event*, a basic unit of energy-exchange. Then we’ll see how events with certain arrangement can match the features of consciousness.

4. Basic unit of energy-exchange

Action potentials, also known as “nerve impulse” or “spikes”, are the leading role of information processing and transmission in the nervous system. Regardless of cell size and shape, “signaling is organized in the same way in all nerve cells ¹⁰”. We can zoom in by using imagination to see some essential details of an action potential. Here is the very concise description of an action potential processing in a typical neuron.

A neuron is wrapped by a membrane composed a double layer of phospholipids with proteins embedded in it. The difference in electric potential between the inner and outer of the neuron cell is called membrane potential. When the neuron is at rest, there are thin clouds of positive ions spread over the extracellular surface and negative ions over the intracellular surface, because the voltage outside the membrane is defined as zero, membrane potential is negative at rest and is held at a relatively stable value(around -65 mV). An action potential is the membrane potential of a certain region rapidly rises and falls, which is called impulse, and travels from one region to another region, down the axon in one direction only, to the axon terminal. The changing of the membrane potential is caused by influx and

efflux of ions pass through ion channels, which are proteins span the membrane. Most ion channels have open and close states in response to stimuli, and allow or prevent ions crossing the cell membrane. Ions pass through the ion channels under electrostatic and diffusional driving forces across the membrane and result in the changing of the membrane potential.

At the beginning of an action potential, neurons receive stimuli from external environment or other neurons. Stimuli can be physical or chemical. Specific ion channels such as mechanically gated channels or ligand-gated channels are opened in response to specific stimuli. Ions such as sodium flow into the neuron and rise the membrane potential. Once the membrane potential reaches a certain threshold, it will open voltage-gated sodium channels, and more sodium ions flow into the neuron, which gives a further rise in the membrane potential and in turn opens more channels, and so on. The process acts like positive feedback loops, results in a large upswing in the membrane potential. Once the membrane potential rises to certain level, sodium channels close and sodium ions stop enter the neuron, potassium channels open and potassium ions exit the neuron, these would cause the membrane potential to fall back to resting state. The rise and fall of the membrane potential are happening in one region, but the influx of ions would diffuse to adjacent regions in the neuron, cause the membrane potential of adjacent regions to rise and may trigger an impulse in these new regions. Consequently, the impulse travels down the axon to the axon terminal, at there, the impulse causes the opening of voltage-gated calcium channels, and results in a large calcium ion influx which increases the concentration of intracellular calcium ions, causing vesicles containing neurotransmitters to fuse with the membrane and release neurotransmitters into the synaptic cleft. The released neurotransmitters diffuse across the synaptic cleft and may become the chemical stimuli of the postsynaptic neuron and cause which to generate an action potential.

There are two key sub-processes in the process of an action potential, one is the opening of ion channels, and the other is the movement of ions, especially the influx of sodium or calcium ions. The closing of ion channels and the efflux of ions can be bypass because they are only essential for the regeneration of action potentials and getting the membrane potential back to its resting state, but are not essential for the conductive function. Different types of ion channels may be opened by different ways, for example, mechanically gated channels can be opened by pressure or stretch, involve exchange or transform of mechanical energy or motion energy, other channels may involve exchange of chemical, electrical, thermal energy, etc. The influx of ions is driving by electrostatic and diffusional driving forces, from a microscopic perspective, it is the exchange between electrical energy and motion energy. We can see that all of these sub-processes are involve energy exchange, therefore, we can use the term *event* to refer to a process of energy exchange (or doing work), that is, as long as there is energy exchange, it can be regarded as an event. An event can be considered as a basic unit of energy-exchange, just like elementary particle for matter, but their characteristics and the ways of combining are very different.

According to the definition of event, the process of an action potential can be decomposed into plenty of events, even the sub-processes like influx of ions, also contains a large number of events, if we zoom in at the subatomic length scale, the number of events will become astronomical. It seems that the concept of event makes the problem

more complicated, so we need to find some principles that, step by step, unite these events or cut off some of them. First, we need to look at the characteristics of the event.

(1) An event must involve at least two or more material objects, and they can be called object collection of the event. An event also involves interactions and relative motion. An event is not equal to its object collection, and one object can be involved in different events at the same time. For example, two little balls are in free fall at the same time, they are all attracts by the earth, it can be regarded as two different events, and the earth is involved in two different events at the same time.

(2) there is only one way to connect two different events, that is to cause or to be caused, and the events are in a causal connection or simply a connection. For example, if there is a connection between event E_A and event E_B , it should be E_A causes E_B or E_B causes E_A , but only one of the situation is possible since the causal connection is unidirectional. If E_A causes E_B , E_A can be called preceding event of E_B , and E_B can be called succeeding event of E_A . If E_A causes E_B and then E_B causes E_C , then E_C causes E_D , and so on, this situation can be called event-chain, and it is also unidirectional. The process of an action potential can be regarded as a process in which one event causes another from the stimuli input to the release of neurotransmitters, so it can be regarded as an event-chain, the closing of ion channels and the efflux of ions are events that make no contributions to this event-chain, as a result, they can be bypassed.

There can be no energy exchange between two events that have causal connection. For example, a sodium channel opens and a sodium ion passes through, these are two events have causal connection, because without the opening of sodium channel, the event of sodium ion passing through would not occur, but there is no direct energy exchange between them. This implies that the object collections of the events can be no intersections(forces) with each other, so there can be no energy exchange between two collections. Take an action potential for example, it can be regarded as an event-chain, but it does not mean that energy is transferred from its start to its end.

(3) An event proves its existence by causing other events, this can be called the *effectiveness* of an event. For example, if event E_A causes event E_B , then E_A is existed (or effective) for E_B . It does not make sense to simply say that an event exists, if an event does not cause any other event, then the event will be an isolated event, whether it exists is meaningless. There is a question that often causes controversy, “the tree in the forest that falls. Does it make a sound? ¹³” If applying the idea of “effectiveness”, the falling of the tree is not an effective event, it is meaningless to talk about its existence, because we can’t prove either its existence or its non-existence.

(4) Event is discrete, “to be or not to be”, that is, either occurs(exists) or not occurs, there is no intermediate state between the two, it is the only property of an event. Just like atomic experience, an event has no magnitude, dimensions or unit. According to the definition, an event is a process, and a process has duration, but it is not the property of an event, because the duration of an event is invisible for its succeeding events.

(5) Events can be confined in specific structures of matter. For example, events generated by the interaction between protons, neutrons, and electrons that make up an atom, do not cause any event outside the atom, so the events are ineffective or invisible for the outside atom. The interaction between atoms is mainly electrostatic, which acts on

the charged particles such as protons or electrons inside the atom, but it changes the motion state or energy level of the entire atom, so in general, the atom acts as a unity, regardless of how energy is exchanged inside the atom. For many molecules, the situation is similar to that of atoms, and each of them is involved in the event(s) as a unity. At the level of neurons, the situation is a bit more complicated, because the energy required for neuronal activities, including action potentials, comes from metabolism, which is complex processes that involve many events.

As discussed earlier, consciousness is a set of atomic experiences, and there are some common features between an event and an atomic experience, so we can first assume that an event is an atomic experience, that is, an event is identical to an atomic experience, not “merely correlate with it”³, nor give rise to it, no transform, no extra ingredient.

5. Organization of events

In a causal connection, there are several possible situations in terms of the number of events that causing and being caused:

(1) The simplest case is that one event causes one another event, it can be called 1:1 connection. As we have seen earlier, an event-chain is one event causes another event, which would cause one another event and so on, so 1:1 connection can also be called chain connection. Event-chain can be considered as a continuation of an event, that is, the entire event-chain can be considered as a single event.

(2) One event cause two or more events, i.e. 1:n ($n \geq 2$), it can be called divergent connection, or simply divergence. For example, the opening of an ion channel cause many ions flowing into the neuron is a case of divergence.

(3) Multiple events cause a common event, i.e. n:1 ($n \geq 2$), which can be called convergent connection, or simply convergence. For example, after ions flowing into the neuron through the ion channels, the ions will diffuse to adjacent regions down its concentration gradient, causing voltage-gated ion channels to open, opening of each channel can be regarded as an event, which is caused by the events that ions gather together, so it's an n:1 connection.

(4) An event without proceeding event, i.e. 0:1 connection. Actually, this situation does not exist, but sometimes for the convenience of problem analysis, some events can be treated as this situation. For example, sensory cells receive stimuli from the outside world and generate action potentials can be approximately considered as 0:1 connection, because there is no preceding action potential to cause sensory cells to generate action potentials.

(5) An event without succeeding event, i.e. 1:0 connection. This situation is only theoretically possible, but also for convenience we can regard some situations as 1:0 connection, for example, if an action potential does not cause any other action potentials, it could be considered as 1:0 connection.

Some other situations can be considered as a combination of one or more situations, for example, 1:n:1 can be simplified to 1:1, and n:n can be considered as a combination of n:1 and 1:n.

Events with causal connections can constitute an event set, for example, event E_A causes E_B and E_C , then E_C and E_D together cause E_E , all of which are included in an event set that can be called causal set. Given a causal set, any event in this set has a causal connection with one or more events in the set. Causal set is an ordered set organized in chronological order, and is unidirectional on the time axis, flowing like a river, and a causal set can also be called

an “event-stream”. In an event-stream, all events that occur at a certain moment also constitute a subset of the event-stream, which can be considered as a *cross-section* of the event-stream.

We have assumed that an atomic experience is identical to an event, then consciousness—a set of atomic experiences, is identical to a set of events, but not any set of events can constitute consciousness, for example, suppose there are two persons, each one has many events in the brain, but neither can experience the experiences of another. As discussed earlier, consciousness is a set with a certain range, so we need to find some constraints to make the set of events equal to an effective consciousness. From the previous analysis, we can know that causal connection is the only way to connect events, so we can propose the first constraint principle: conscious experience is an event-stream. This principle seems to be able to limit the set of events to a controllable range, but the situation, as we will see, is not so optimistic, and more constraint principles are needed.

As discussed earlier, there are several connection types, an event-stream may have all types at the same time, and they would shape the event-stream. Consequently, we need to examine which types are necessary to form an effective consciousness-stream. From the previous analysis, we know that the 1:1 connection can be regarded as one event. The 0:1 connection can be the beginning of an event-stream branch, such as events that are generated by sensory neurons, they are the essential constituents for an event-stream. The 1:0 connection can be the termination of an event-stream branch, because there are no succeeding events, so it is ineffective.

The divergent and convergent connections are a little more complicated, we can examine the divergent connection first. Suppose there is a divergent connection that event E_A causes E_B and E_C , E_A is effective because both E_B and E_C can prove the existence of E_A . But E_B and E_C can be considered as independent from each other, because whether E_B occurs does not affect whether E_C occurs, and vice versa. Consequently, E_B and E_C can't form a unity. Divergent event-stream is similar to biological reproduction, after several generations of reproduction, the number of descendants may increase exponentially. If there are no restrictions, from the Big Bang (if the Big Bang theory is correct) to the present, all the events in the entire universe can be regarded as an event-stream because of the divergence. In a brain, even if we set the start time of the event-stream to the point that sensory neurons receive stimulation, because of circulatory system and metabolism, as time goes on, the event-stream will soon spread throughout the body, and finally, spread outside the body, which is inconsistent with “real-life” consciousness. Therefore, the divergent connection cannot be the constraint principle.

Convergence is opposite to divergence, as time goes on, the number of events will decrease, and they will eventually converge into one event. Suppose there is a convergent event-stream, event E_A and E_B together cause E_C , and E_D and E_E together cause E_F , E_C and E_F together cause E_G , E_C is the proof of the existence of E_A and E_B , so do E_F and E_G , therefore, E_A , E_B , E_C , E_D , E_E , E_F are all effective, if E_G keep converging with other events and go on, the event-stream they have formed can be considered as a unity.

From the above analysis, we can propose the second constraint principle, which add to the first constraint principle is: conscious experience is an event-stream with convergent connection. But it is still not sufficient for forming an effective consciousness. This can be revealed by a thought experiment, which can be called “the external brain

experiment”. Suppose there is a person with a brain A, another person with a brain B, according to the second constraint principle, each brain has an independent convergent event-stream, the cross-section of each event-stream at a certain moment, would inevitably converge into a single event at a certain moment in the future because of convergence, so we can connect two brain with a single pathway, namely an axon, from brain A to B, if the two constraint principles is sufficient for forming a “seems to be normal” consciousness, then brain B should be able to experience what brain A can, but this conclusion is obviously absurd.

There are two subtypes of convergence, one is similar to “OR” in logic, and the other is similar to “AND” in logic. Assume that event E_A and E_B converge into E_C , if either E_A or E_B occurs can cause E_C , we can call this kind of convergence as an OR-type convergence. If E_A and E_B must occur together to cause E_C , and any one that does not occur, E_C will not occur, then we can call this kind of convergence AND-type convergence. In the external brain experiment, the event-stream of brain A converges to the event-stream of brain B through an axon and merges into a single event-stream, this is an instance of OR-type convergence. From the result, events in an OR-type convergence can be considered as one single event. Therefore, we can propose the third constraint principle, which add to the first two constraint principles is: conscious experience is an event-stream with AND-type convergence.

Suppose that in an event-stream with AND-type convergence, event E_A and E_B converge into E_C , if there is an event E_D would like to converge with E_A and E_B to cause a new event, suppose that is E_x , then E_x must different from E_C , because if E_A , E_B , E_D still converge into E_C , that is, whether E_D occurs or not, E_C may occur, which is OR-type convergence. Therefore, AND-type convergence can also be described as, different combinations of events will converge into different events. Take the external brain experiment for example, because brain A may have different experiences at different times, in other words, brain A may have different combinations of events at different times, if brain B wants to experience all the experiences of brain A experience, one neural pathway is not enough, we need more pathways to connect brain A and B, so that for each combination of different events in brain A, merges into brain B through a unique pathway.

an event-stream with AND-type convergence, would seem like an inverted tree structure. As discussed later, this type of event-stream has many similar features with consciousness, so we can assume that an event-stream with AND-type convergence are identical to a consciousness-stream. A cross-section of this event-stream is identical to the instantaneous consciousness of a certain moment. With the passage of time, if no new events converging into the event-stream, the cross-section of which will become smaller and smaller with time, and eventually converge into an event, in other words, consciousness will become less and less, finally disappears. It is inconsistent with “real-life” consciousness. Therefore, it can be inferred that the convergent event would converge into a new event-stream and become its input, so that the event-stream can be supplemented and the cross-section will not become smaller.

6. Consciousness is effective at the neuron level

Another understanding of OR-type convergence cannot be a constraint principle is that multiple inputs(events) of OR-type convergence can be regarded as a single event. For an action potential that occur within a neuron, there are 1:n:1 connections that can be considered as many single events, and from inputs to the outputs, many of them are

OR-type convergence, so an action potential can be considered as an single event. But the reverse is not true, “different neurons in the pathway perform similar computations simultaneously ¹⁰”, they would form OR-type convergence, therefore, they could be regarded as a single event. In summary, an event that identical to an atomic experience exists at the neuron level and consists of one or more parallel action potentials.

Although many events do not directly contribute to the organization of the event-stream, they are the basis for maintaining life and ensuring the processes such as action potentials working normally, for example, ion pumps transport ions out of a neuron, ensure that the next action potential can be carried out normally, these events may converge to the next action potential. These events are necessary for all of the neurons in our brain, so the convergence which these events converge to the action potentials can be regarded as AND-type convergence, so they are identical to atomic experiences, but we don’t seem to have experienced these atomic experiences. One possible explanation is that they can be thought of as a common divisor, which can be eliminated. Another possible explanation is that they make us feel alive or aware.

7. Explanations

As discussed earlier, we propose three identical relationships between subjective and objective, namely, an event is identical to atomic experience, and an event-stream with AND-type convergence is identical to a consciousness-stream, a cross-section of an event-stream with AND-type convergence is identical to the instantaneous consciousness at a certain moment. They provide convenience for the explanation of many phenomena, but also introduce some new problems, there are three problems about the “same” that we need to answer:

Problem 1: The location where an event occurs can be called a *unit*. In our brain, a unit may be a neuron or neurons in a neural pathway. A unit can generate events at different times, and each event is a totally new event, because “no one ever steps in the same river twice (Heraclitus)”, why can these events be the same experience?

Problem 2: Why can events generated by different units have the same experience? For example, different areas of the retina can perceive the same color, different areas of the skin may feel the same touch.

Problem 3: Why can different persons have the same experience? For example, we may have the same experience of seeing red. Someone may argue that it is not true because we cannot directly perceive the experiences which perceived by others, the experience of seeing red may be different between two persons. We don't have to be bothered by such argument, because the problem comes from the “same”, not the “difference”.

Features Matching

As discussed earlier, events or set of events organized in a certain way obviously have features 1 to 4 of consciousness, so here we can start matching from feature 5.

Matching Feature 5: An event-stream can be considered as a unity because of causal connection between events, by adding the constraint principles, the event-stream becomes smaller, so the unity would be more compact. As the example presented in earlier section, event (E_A, E_B) cause E_C , (E_D, E_E) cause E_F , (E_C, E_F) cause E_G , if this is an event-stream with AND-type convergence, then, for E_C , events (E_A, E_B) are a unity that anyone of them cannot be

cut off, because one of them does not occur, E_C will not occur. And for E_G , events ($E_A, E_B, E_C, E_D, E_E, E_F$) are a unity, anyone of them does not occur, E_G will not occur. For any cross-section of an event-stream with AND-type convergence, there is always an event (suppose it is E_X), if any event in the cross-section does not occur, this event (E_X) will not occur. If the figure formed by a cross-section and its converging events is regarded as a cone, then the event (E_X) is the vertex of the cone with the cross-section as its base.

We can look at this example in an equivalent way of understanding, that is, E_A and E_B cause E_C , which can be understood as E_C experiencing E_A and E_B . Likewise, E_G can experience $E_A, E_B, E_C, E_D, E_E, E_F$, because any of them does not occur, E_G will not exist.

According to feature 5, consciousness is a unity with a range, and indeed, we seem to feel that consciousness has a certain range. But instantaneous consciousness is the cross-section of an event-stream, events in this cross-section have no causal connection with each other, because events with causal connection cannot occur at the same time. The range of instantaneous consciousness is determined in the future by causal connection—convergence. It seems as if we can foresee the future. Excluding this sci-fi explanation, one possible explanation for this problem is that the “experience of range” is about the past, not about the instantaneous consciousness at present.

Matching Feature 6: Event is discrete, to be or not to be, and more specifically, it is to be “something”, or not to be “something else”, and not to be “everything” (it can be inferred that matter is to be “everything”, because most of them are existing all the time). For example, suppose there are three neurons, namely N_A, N_B , and N_C . N_A can respond to the stimulus of red light, N_B to blue light, and N_C to middle C. If there is an incident red light at time T_1 , N_A could generate event E_A , which identical to an experience of redness. If there is an incident blue light at T_2 , N_B could generate event E_B . If there is a middle C at T_3 , N_C could generate event E_C . If there is an incident red light at T_4 , N_A could generate event E_D . At T_1 and T_4 , E_A and E_D are existing for the incident red light, and at T_2 and T_3 , N_A does not generate any event because there is no incident red light, so E_A is different from E_B and E_C , but equivalent to E_D in terms of “something” it is to be, for E_A and E_D , “something” is the incident red light. The “something” can be understood as the meaning or intentionality, because it means or directs towards “something”. The “something” can also be understood as a point in a virtual space, which can be called “meaning space” or “intentionality space”.

Matching Feature 7: Suppose there are two neurons N_A and N_B . N_A can respond to the stimulus of red light in area A, N_B can respond to the stimulus of red light in area B. If there is an incident red light in area A, N_A could generate event E_A . If there is an incident red light in area B, N_B could generate event E_B . As discussed earlier, an event is identical to an atomic experience, so it seems that E_A and E_B should have the same experience of redness, but E_A is existing for an incident red light in area A, which can be regarded as a point A in the “meaning space”, and E_B is existing for an incident red light in area B, which is point B, E_A and E_B are different. This seems to be a contradiction. One possible explanation is that any one of E_A and E_B is able to cause another common unit to generate event, assuming E_C , which is identical to the experience of redness. E_A or E_B may not cause E_C every time, which may be the reason why there is red light incident but we may not aware of redness.

We can call experiences such as redness, blueness, a shape of line, etc. as conceptual experiences, because a conceptual experience is the commonality of different events. One event may cause different conceptual experiences. For example, an event of visual input may cause color experience, or experiences of different shapes. Different conceptual experiences may also have commonality. As the example that presented in earlier section, events E_A and E_B may cause conceptual experience E_C , events E_D and E_E may cause conceptual experience E_F , conceptual experiences E_C and E_F may cause conceptual experience E_G . In this example we can see that events (E_A , E_B , E_D , E_E) are at the same level, events (E_C , E_F) are at the second level, and E_G is at the third level, We can use the term “distance” to refer to the level difference of the conceptual experience formed by two events, namely, the distance of E_A and E_B is 1, because they are at the first level, and they form a conceptual experience E_C at the second level. The distance of E_A and E_D is 2, because they are at the first level and they indirectly form a conceptual experience E_G at the third level. The distance between events can be used to explain why some experiences look very different and some not quite so different. For example, the difference between experience of redness and blueness, “looks” less different than the difference between seeing red and hearing middle C, probably because the distance of the former is shorter than the latter, the former may have more commonalities than the latter.

the self

when we are awake, it seems that there is always an “I” as an observer to experience every experience, and as a commander to give instructions and take charge of the body. The “I” has many titles, including the most famous one—the self, or true self, to distinguish it from the autobiographical self. It seems that the self is an entity independent from experiences, this is so-called “Cartesian dualism”¹³, it makes the explaining extremely difficult, so most people abandon this point of view, and some even abandon “the self” by the way. But again “I think therefore I am”, the self seems hard to be denied. One possible explanation is, the self exists, it is the experiences themselves, every experience can be thought of as “I experience something” or “I have(own) the experience of something”, this is an equivalent understanding and does not mean that we can separate the self from the experience. This idea can be understood from two aspects. One is that the self is effective immediately, it is real-time, as opposed some traditional views which believe that the self is continuous, therefore, there is no “shifting problem” for this understanding, the self is not shifting from one place to another place. The other aspect is that every experience is mine, not someone else’s, we can never have an experience as “your experience” or “her experience”, the experiences are always mine.

Suppose we can duplicate one person completely, atom by atom, within one nanosecond, then we have no reason to believe that they have different selves, which means that one of them can experience that the experiences are not mine. There are some unreasonable points in this assumption, but the logic is the same between different persons and duplicate persons, the self is always the same, no matter it is noble life or humble life.

This can also be used to explain why there is always only one self in our mind, From the previous discussion we know that a consciousness-stream is identical to an event-stream, it is a unity, the self is also this event-stream itself, so it is a unify single self. There may be more than one event-streams in our brain at the same time, many unconscious processes can be considered as independent event-streams, which do not converge into the (relative)main stream,

once these “unconscious” event-streams converge into the main stream, they will become a unity, so again, there is only one self. The term “unconscious” is not quite correct, because they can be conscious too, and they may have self, the reason why they don’t “think” they have a self is that they don’t “think” that much as the main stream do.

Why there is “something it is like”

We have assumed that experiences are identical to events and the self is experiences themselves, if this assumption is correct, under this prerequisite, it becomes possible to answer why there is always something it is like. Suppose there are an event set, namely S_A , converge into our consciousness-stream, as a result, we can experience S_A , there must be something it is like, it is impossible that we can experience something but there is nothing it is like. From the previous discussion, we know that everyone has the same self, then something it is like has nothing to do with who own it, only depends on what it exists for. From this conclusion we can infer that different people can have same experiences, for example, two persons can have the same experience of redness, and so do other experiences.

Digital computer cannot be conscious

The Chinese room argument shows that a digital computer cannot have consciousness¹⁴. Here we can explain it from another perspective—the physical foundation. Modern computers are based on digital circuits, which use HIGH and LOW voltage states to represent 1 and 0 (sometimes HIGH represents 0 and LOW represents 1, depending on the designer’s or user’s definition), and then use specific combination of 0 and 1 to represent specific information. Some people may think that these states are combined and presented according to certain rules, and then consciousness can emerge. According to the opinions put forward in this article, there are two conditions are not satisfied. First, the voltage state is not energy-exchange, and second, there are no causal connections between the states. This can be illustrated by an example.

A computer can be abstracted into a simplified model which contains a data set, a rule set and execution unit. The data set contain a large amount of data bits. The state of each data bit can be altered by execution unit in real time. The rule set contains rules which determine the state of each data bit in the data set at any time. The rule set is a static set, and the rules are designed in advance. The execution unit alters the state of the data bits in the data set in real time according to the rules in the rule set.

The assumption that computers can possess consciousness is that, at any time, as long as any bit in the data set is in a proper state, consciousness will emerge. Then we can assume that there is a rule set A, which makes the data bits in the data set in a proper state and generates consciousness. We know that in computer science, both HIGH voltage and LOW voltage can be used to represent 0, and can also be used to represent 1, as long as we have a way to distinguish. Therefore, we can add some rules to rule set A, so that when a certain data bit should be HIGH, switch its representation value, that is, if the original HIGH level represents 1, then when a certain data bit should be 1, switch to use LOW to represent 1. These changes have no effect on the function and representation of the computer, if it had consciousness before, it will also have consciousness after updating. But after the update, all data bits in the data set will always stay LOW. This doesn’t look like it has consciousness.

8. Conclusions

In this article, we establish a reductionistic and physicalistic explanatory framework for consciousness base on the known physical laws, and it may serve as a model for neuroscience and artificial intelligence. We propose that the consciousness is processes of energy-exchange because there are many problems with matter and fields, this does not rule out the possibility of solution for matter and fields. So, this framework does not deny other possibilities.

Consciousness look so different from their physical realization, we may probably not understand why they are the same thing, the explanatory gap may always exist, so the solution propose by this framework may be a good choice, find out their essential features, then matching these features, gradually narrowing the gap, when the gap becomes narrow enough, we can easily jump over it.

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