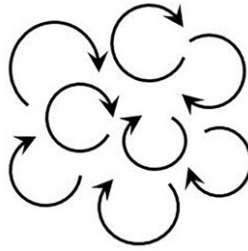


The Basic Theory of the Mind

A Physical Theory about What We are



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Dr. Chirapat Ukachoke

Second Edition

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List of Abbreviations

Abbreviation	Definition
AI	artificial intelligence
ECoG	electrocorticography
EEG	electroencephalography
E/EC	electrical/electrochemical
EPP	electrical/electrochemical-signal-processing process
fMRI	functional magnetic resonance imaging
Hz	hertz
IPP	information-processing process
MEG	magnetoencephalography
ms	millisecond
mya	million years ago
SP	signaling pattern
SS	signaling state
SSP	special signaling pattern
SSS	special signaling state

Preface to the First Edition

The mind has always been a great puzzle for those who try to comprehend it. What is it? Is it a separate entity from the brain, or are they the same entity? Why are there the mind, the consciousness, and the phenomena called qualia? What is the purpose of having them in this universe? How do they occur? And many other questions.

Fortunately, for centuries, a lot of neuroscientists and other scientists and researchers in related fields have gathered a lot of information related to these questions, and they and many philosophers have formed a lot of useful ideas and theories regarding these questions. So, we now have a wealth of scientific evidence and concepts that are complete enough to form a theory that can resolve this great puzzle.

I think that many concepts in this theory, such as that the mind is closely associated with the brain and that mental phenomena are closely related to neuronal functions, have been around in the scientific community and have been the bases for experiments regarding the mind and mental processes for a long time. However, they have never been proved explicitly and rigorously. Also, although there are many scientific theories about some important aspects of the mind, such as about qualia and consciousness, there has never been a basic theory that systematically deals with the fundamental nature of the mind as a whole. Therefore, I consider that it is necessary to prove the basic concepts about the mind as a whole scientifically and state them definitely as a theory with organized theorems so that they can be understood clearly and quickly and can be the targets for further scientific investigations. By doing this, some new concepts such as that mental processes are the information-processing processes of neural circuits and that qualia are some forms of neural signaling patterns have emerged. They are found to be the keys to understanding the important issues such as the nature of the mind and the hard problem of consciousness. Also, I think that an explicit theory will help future generations and new investigators in this field quickly get the idea of what the current scientific concepts regarding these matters are, what concepts are still incomplete, and what remains to be done. In addition, I hope that this theory will help the general public understand the concepts easily in a short time and that they will become more interested in this important issue of life.

This theory is a physical theory, not a philosophical or psychological theory. Its main objectives are to answer the questions, based on scientific evidence, of what the mind and its associated phenomena, such as qualia and consciousness, are, why they occur, how they occur, and other related questions. It is a basic theory that deals with only the fundamental concepts; it does not answer the specific questions such as what exact neural

circuits create qualia and consciousness or what the exact characteristics of signaling patterns that can create them are. However, at present, great advances are being made regarding these specific questions, and one can find the present or potential answers in the current literature in cognitive neuroscience and related fields.

Whether this theory is correct or not remains to be verified by experiments. Nevertheless, whether the theory is finally proved to be correct, partially correct, or incorrect, I really hope that it will lead to discussions and experiments that will help advance our understanding of the mind.

Dr. Chirapat Ukachoke

October 18, 2018

Preface to the Second Edition

It has been over five years since the first edition of this theory was published. Many things have changed in the meantime. On the part of the scientific world, there has been a remarkable outpouring of literature, both philosophical and physical, on the mind, consciousness, qualia, and related issues. Also, there has been a concurrent, interesting development: Recent literature has become more and more experiment-based instead of mainly argument-based. This is a positive change because it has generated new, testable concepts and theories regarding these matters, and being able to test them helps us make corrections and improvements, resulting in better and more accurate concepts and theories. As for this theory, although the number of published articles on these matters has been increasing almost exponentially and even though it is becoming impossible for anyone to keep up with all of them, I have tried to incorporate a wide range of significant literature from this vast resource as references to ensure that the theory is firmly based on current scientific evidence and concepts.

On my part, because of the added literature and continued study of these subjects, I have gained a deeper understanding of them. This has made me appreciate the inherent equality between the non-material mind and material brain more and better comprehend the nature of the mind and its phenomena. Accordingly, several modifications and refinements have been made to the theory. The way Theorem I is stated in this new edition reflects the realization—it does not assert that the mind is part of the brain as it did in the first edition. Slight changes have been made in the phrasing of Theorems IV and V to state each of them in a more basic form, while all other theorems remain the same. The wording of some definitions has also been adjusted to make them more precise. Two noteworthy changes are that the definition of a quale has been modified to reflect its connection with consciousness more clearly and that the definition of information has been refined to specify more accurately what information is in this theory. Lastly, the name for qualia that manifest themselves variably among people has been changed from “different qualia” to “variable qualia” to characterize their nature more appropriately.

Regarding the content of the theory in this new edition, “a point-of-view approach,” which is a new and easier-to-understand way to investigate and explain how non-material, phenomenal qualia and consciousness can occur in material, non-phenomenal physical systems, such as the brain and neural circuits, has been added. Also, a new chapter has been created for “information” to delineate the derivation of its definition and discuss its nature, which is crucial to solving the puzzles about qualia and consciousness. As for the arrangement of other chapters, the chapter on consciousness has been expanded and split

into two chapters to accommodate new content. In addition, because of their details and importance, this edition presents the explanatory gap and the hard problem of consciousness in two separate chapters. On the other hand, minor theorems have been grouped into one chapter, and Variable Qualia and P-zombies have been moved from regular chapters to extra chapters because they are not part of the theory proper.

As remarked in the first edition, this is a physical, not philosophical or psychological, theory. Its main objectives are to answer, based on scientific evidence, the questions of what the mind and its unique phenomena—qualia and consciousness—are physically, why they occur, how they occur, and other related questions. As a physical theory, it provides scientifically testable predictions so that its concepts and theorems can be objectively verified. However, it does not answer advanced neuroscientific questions, such as what exact neural circuits and processes generate qualia and consciousness, which are the subjects many scientists worldwide are actively investigating. It is a basic theory that deals with only the fundamental concepts, which are still not well established.

Overall, this second edition investigates the mind and its phenomena more thoroughly, with additional evidence and means of investigation. Accordingly, I hope that it will provide the scientific community with new, useful concepts and better ways of tackling and unraveling these puzzles, which are among the most important matters in science.

Dr. Chirapat Ukachoke

June 10, 2024

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Lastly, the author is grateful to PubMed (<https://www.ncbi.nlm.nih.gov/pubmed/>), which has been an essential source of a large number of valuable publications, to various informative websites on the internet, and to all the authors who have published their works that I have used as resources and references.

Dr. Chirapat Ukachoke

June 10, 2024

*The answers exist in
the physical properties of
the mind, qualia, and consciousness.*

Introduction and Definitions

One thing that has always fascinated us is the mind. It is the only thing that we can be certain of existing, yet we do not know what it is. This contrasts with things outside it. We cannot be certain that they really exist—they may be just illusions. Still, we apparently know what they are. We also have ample information about them. For example, we know that an apple is a material object composed of fruit cells, with about 85% water content, full of vitamin C and fiber, and almost without fat. Even in the case of something that is non-material, such as an electromagnetic wave, we can tell that it has zero rest mass, travels at speed c in a vacuum regardless of the measuring frames, and possesses the dual nature of being a wave and a particle; we can even write formulas to describe its properties. Moreover, for both, we can answer the questions of what they are basically composed of (the apple, a mixture of several kinds of elementary particles; the electromagnetic wave, only one kind—the photon) and how and why they occur. We cannot do such things in the case of the mind. What we know about the mind is only that it is non-material, can perform various mental activities, such as sensing stimuli, thinking, and executing motor commands, and has observable functional properties, such as being private, subjective, and intentional [1–9]. However, we do not know, among other things, what it is physically and ontologically (i.e., what it is composed of), how it occurs in the material world, and why it occurs in this universe.

In the past, these conundrums persisted probably because there was little objective, scientific evidence for thinkers to resolve them; there were only subjective observations of their minds and others' behaviors. However, the situation has changed over the past century. Objective methods of observation using various types of scientific instruments, such as electroencephalography, magnetoencephalography, and functional magnetic resonance imaging, have been developed and employed in the investigation of the mind, resulting in a large number of empirical results. Accordingly, we now have a wealth of both subjective and objective evidence as a basis for building theories that can unravel the above puzzles. Owing to this, both physical and philosophical theories about the mind and its phenomena, especially qualia and consciousness, have been increasingly published over the past few decades (for example, References 8,10–23). Yet significant progress has been made mainly in the area of the easy problem [24–30], or the problem of what the neural circuits and processes for the mind and its functions (such as perception, cognition, and motor execution) are; little advance has been made regarding *the ontological problem* (or the problem of what the mind and its phenomena fundamentally are), *the hard problem* [9,11,24–38], and *the explanatory gap* [9,25–30,33,37–48] (or the problems of why and how they occur). Hence, this theory will strive to answer these last three problems and other associated issues using current scientific evidence.

However, before the attempt begins, it is imperative to note that one of the factors that hinder progress in attacking these three problems is that definite definitions of the mind, qualia, consciousness, and several related terms have not been established. This lack of definite definitions has persisted even up to now despite extensive debates on these matters for a long time. Without standard definitions, confusion and misunderstanding of these terms can occur, especially when they are used without specifying the definitions being used. Such confusion and misunderstanding limit the interpretation and utilization of those works and impede progress in solving the puzzles.

Because many special terms will be used in this theory, to avoid such setbacks, these terms will be defined specifically at appropriate points in the theory. The theory chooses, among various definitions, the ones that not only seem to be commonly used by the general public and academia but also define entities that are scientifically testable. The aim of this theory is not to assert the best definitions but to find what entities as defined by this theory's definitions physically and ontologically are, why and how they occur, and other answers to associated questions. Thus, all set-up definitions are working definitions for use in this theory. Hence, caution should be exercised when comparing literature using these terms as they may have different meanings.

Some terms are used throughout the theory from the beginning and are defined in this chapter as follows:

D1. Mind

"Mind" is the principal term in this theory. Therefore, it will be analyzed in detail before it is defined.

D1.1 Meanings of the word "mind"

To properly define mind for scientific investigation is not a straightforward task. We have to find something that is both (I) acceptable to be mind in the usual sense and (II) amenable to scientific investigation. Nevertheless, this can be achieved as follows:

First, let us examine what the word "mind" can mean. We will find that it, like many other words that have no definite definitions, has various meanings depending on many factors, such as personal factors (e.g., the person's belief, culture, and religion), the aspect that is being focused on (e.g., functional, anatomical, or ontological), and the context of usage (e.g., psychiatric, physical, or philosophical). For example, the words "mind" in the following sentences have at least slightly different meanings: "*She tries to keep her **mind** on what she's doing*"; "*Albert Einstein had a truly beautiful **mind***"; "*Children usually develop theory of **mind** during preschool years*"; "*Universal **Mind** is the formless energy that animates all of life*"; and "*One of the most difficult philosophical problems is the **mind-brain** problem.*" Moreover, it can sometimes be used interchangeably with closely

related words, such as soul, spirit, psyche, and consciousness [1,9,26,36,49–70], which can cause even more confusion.

In the ontological sense, which is an important sense and the sense in which this theory examines the mind, the word “mind” can be used to mean *an alive, non-material entity* that exists in

i) **every physical object**, which comprises both living and non-living objects (such as rocks, rivers, clouds, computers, and robots; and even up to stars, galaxies, and the universe; and down to molecules, atoms, and elementary particles)—the belief of panpsychism [66,71–78], or

ii) **only every living thing**, which comprises animals and non-animal organisms (such as plants, fungi, algae, amoebae, and bacteria)—the belief that may involve the concepts of vitalism, life force, and the three forms of soul, that is, vegetative, sensitive, and rational souls [79–86], or

iii) **only every animal**, which comprises humans and non-human animals (such as dogs, birds, fish, insects, and sponges) [87–89], or

iv) **only every human** (e.g., Descartes and people in some religions and cultures believe that only humans have minds, but animals—or mindless automata, as Descartes referred to them—and everything else do not [90–92]).

In the above description, that the entity is *non-material* means it is *not composed of material substance*, and that it is *alive* means it *performs activities*—not simply existing without doing anything, which would make it just an abstract, lifeless entity, such as beauty, goodness, roundness, equality, and singularity. If we look into the activities that the mind is generally supposed to perform, we find that they are

a) **sensing signals** from the environment, its physical body, and its non-material self, such as seeing things in the outside world, feeling its body parts, and experiencing emotions in itself,

b) **acting on signals**, such as analyzing, integrating, synthesizing, storing, and retrieving signals, to control body functions and respond to stimuli, such as thinking, planning, making decisions, memorizing things, and recalling events, and

c) **sending signals** to its body parts to control their functions and respond, such as commanding the mouth to speak, hands to work, and legs to run.

Therefore, to be alive in the usual sense means *to perform these three kinds of signal-processing activities*. An alive, non-material entity is thus a non-material entity that performs these activities, which will hereafter be referred to as *the three activities*. Because such an entity—*a non-material entity that performs the three activities*—can be acceptable to be mind in the usual sense, it fulfills our first criterion (I).

Next, let us consider the second criterion (II)—being amenable to scientific investigation. To be amenable to scientific investigation, an entity must be observable and testable using our usual senses or scientific instruments. However, for an entity to qualify as such, it must evidently execute its activities so that it can be observed and tested. On the other hand, if an entity cannot evidently execute its activities but can just hypothetically or imaginarily perform them, we will not be able to observe and test it. It will be a hypothetical or imaginary entity, not a scientific one, and will not be amenable to scientific investigation. Thus, to be amenable to scientific investigation and fulfill the second criterion (II), *an entity must execute the three activities evidently*.

Altogether, for an entity to be (I) acceptable to be mind in the usual sense and (II) amenable to scientific investigation, it must be *a non-material entity that evidently executes the three activities*. This is the type of mind that this theory investigates.

D1.2 Where can we find this kind of mind?

If we want to scientifically investigate this kind of mind to know what it is, why it occurs, how it occurs, and so on, we must first find it in the physical world. The question is where we can find this kind of mind. Can we find it in all entities in the four groups listed in D1.1 or just in some groups?

The answer is that we can find it in things that evidently exhibit the three activities. For things that do not evidently exhibit the three activities, any non-material entities that may exist in those things will naturally not be able to execute the three activities evidently; therefore, it will not be the kind of mind that this theory selects to investigate. However, to find things in which this kind of mind can exist, the previous grouping of entities in D1.1 will not be suitable. Instead, it would be more apposite to regroup entities from the previous four groups into six new groups according to not only what kind of entity each of them is but also what physical system is associated with the three activities in each of them, as follows:

Group I: non-living things that are not computerized (rocks, clouds, stars, galaxies, molecules, atoms, etc.)

Group II: unicellular organisms (amoebae, bacteria, some algae, etc.)

Group III: multicellular organisms without a nervous system (both non-animals [some algae, most fungi, all plants] and animals without a nervous system [Trichoplax, sponges, and mesozoans])

Group IV: multicellular organism parts (cells, tissues, and organs of multicellular organisms)

Group V: multicellular organisms with a nervous system or, equivalently, **animals with a nervous system** (humans and other animals with a nervous system)

Group VI: non-living things that are computerized (computers, robots, and other computerized machines)

Now, let us investigate them in detail.

Group I: non-living things that are not computerized (rocks, clouds, stars, galaxies, molecules, atoms, etc.)

On the surface, it does not seem that entities in this group evidently exhibit any of the three activities, at least not in the usual forms that the general public thinks of. Thus, it may seem impossible for the mind, as stated at the end of Section D1.1, to exist in them. Nevertheless, if we examine these non-living things closely, we will find that they can also be considered to exhibit all the three activities evidently, at least in a technical sense. This is because their parts or components, both macroscopic (such as portions of a rock, cloud, or a star) and microscopic (such as constituent molecules, atoms, or elementary particles of those things), can be considered to *a) sense* signals, which in these cases are forces (any of the four fundamental forces) from other things, *b) act on* these signals, which means dealing with these forces by taking several parameters (directions, strength, patterns, etc.) of the forces and several parameters (positions, mass/energy, electricity, etc.) of all the interacting things into the involved physical rules for results to occur, and *c) send* signals (the resulting or responding forces) to other parts and interacting things as responses. Therefore, at least in the technical sense, these three kinds of signal processing can be considered the three activities although, manifestation-wise, these activities are very hard to recognize and are not familiar to us.

Because things in this group evidently exhibit activities that can be considered as the three activities (sensing, acting on, and sending signals), it is possible that there exists a non-material entity that evidently executes the three activities, or a mind, in each of them. Still, the kind of mind in this group will not be the mind in the ordinary sense that general people think of because the manifestations of its three activities are very difficult to discern, are of the technical kind, and are not those that general people are familiar with or recognize in everyday life.

Another point to be noted is that, in this group, the signal processing of the three activities is basically the processing of fundamental forces, which is the activity of the elementary physical system. Thus, the three activities and the mind in this group are associated with the elementary physical system. We will see that this kind of association differs from those in the other groups, making this kind of mind different from those in other groups.

Group II: unicellular organisms (amoebae, bacteria, some algae, etc.)

Group III: multicellular organisms without a nervous system (both non-animals [some algae, most fungi, plants] and animals without a nervous system [Trichoplax, sponges, and mesozoans])

Group IV: multicellular organisms' parts (cells, tissues, and organs of multicellular organisms)

Introduction and Definitions

Similar to Group I, superficially, it may not seem that entities in these three groups evidently exhibit the three activities—at least not in the usual forms that the general public thinks of. Thus, it may seem impossible for the mind, as stated at the end of Section D1.1, to exist in them. Nevertheless, after scientists have scrutinized these entities, they find that they can also be considered to exhibit all the three activities evidently, but in a rather technical sense. This is because, as is now scientifically established, cells, tissues, and organs can *a) sense* signals, which are mostly in the form of biological molecules (but can also be in other forms such as light, electricity, or mechanical force), from both the outside and the inside of their physical extent, *b) act on* those signals (integrate, store, retrieve, etc.), mostly by biochemical reactions, and *c) send* signals, again mostly in the form of biological molecules, between their parts, and to their effectors to control the entity's functions and respond to stimuli [93–117]. Therefore, at least in the technical sense, these three kinds of signal processing in these three groups can be considered the three activities although, manifestation-wise, these activities are not easily recognizable and are not familiar to us.

Because entities in these groups evidently exhibit activities that can be considered as the three activities, it is possible that there exists a non-material entity that evidently executes the three activities, or a mind, in each of them. Still, like that in Group I, the kind of mind in these groups will not be the mind in the ordinary sense that general people think of because the manifestations of its three activities are not obvious, are of the technical kind, and are not those that general people are familiar with and recognize in everyday life.

In these groups, as discussed above, the signal processing of the three activities is basically biochemical reactions (intracellular and intercellular) of biological molecules and is principally for each individual cell's, tissue's, or organ's survival, with some intercellular signal processing (in the case of multicellular organisms, tissues, and organs) for each organism's survival as a whole to a lesser extent. Importantly, each entity in these groups does not have a dedicated system to connect all its parts into a functional network that can perform the three activities for the entity as a whole. We will see that this deficit makes these groups essentially different from the next group, animals with a nervous system. Lastly, since the signal processing of the three activities in these groups is basically carried out through biochemical reactions—a function of the biochemical system—the three activities and the mind in these groups are associated with the biochemical system. Thus, the kind of mind in these groups differs from that in Group I, and we will see that it also differs from those in the following two groups.

The final point to be noted for these groups is that the three activities performed by the elementary physical system also exist in them because all entities in these groups, like all other physical entities, are composed of elementary particles. Thus, the kind of mind

associated with the elementary physical system also exists in these groups. Hence, two kinds of minds coexist in these groups. This will be discussed in general later.

Group V: animals with a nervous system (humans and other animals with a nervous system)

Unlike the entities in Groups I–IV, humans distinctly exhibit all the three activities. Our close relatives—other animals with a nervous system (mammals, birds, reptiles, fish, insects, etc.) also do—the more advanced in the evolutionary tree, the more distinct. For animals in this group, in addition to having a biochemical system like those in Groups II–IV performing the three activities at the cellular, tissue, and organ levels for the survival of their individual cells, tissues, and organs, respectively, each animal has a new dedicated system—*the nervous system*—overlaying the biochemical system to connect all parts of the animal into a functional network that performs a new set of the three activities at a higher level *for the survival of the animal as a whole*. This new system can *a) sense* (see, hear, smell, etc.) signals via its various specialized sensors (eyes, ears, nose, etc.), *b) act on* (analyze, integrate, store, retrieve, synthesize, etc.) signals, resulting in various mental activities (evaluating, planning, memorizing, recalling, decision-making, etc.), and *c) send* signals to its various parts and effectors (muscles, glands, and other specialized cells) to control body functions and respond to stimuli (by moving, making sounds, secreting something, etc.). Obviously, these three kinds of signal processing can readily be considered the three activities because, manifestation-wise, their activities are distinct and familiar to us.

Because humans and other animals with a nervous system evidently exhibit all the three activities, it is likely that there exists a non-material entity that evidently executes the three activities, or a mind, in each of them. The kind of mind in this group is the mind in the ordinary sense that the general public thinks of because the manifestations of its three activities are obvious and are those that people are familiar with and recognize in everyday life.

In this group, as discussed above, the signal processing of the three distinct activities is performed by the nervous system, which utilizes a new type of specialized cell—the neuron—and a new type of signaling that employs electrical and electrochemical signals and reactions. Thus, the physical machinery that operates the three activities in this group is different from that in Groups II–IV. In addition, functionally, the three activities of the nervous system are mainly for the survival of the whole animal, not just of each individual cell, tissue, or organ, as is the case for the biochemical system. Moreover, compared with those of the biochemical system, the three activities of the nervous system have more pronounced and coordinated effects on the whole animal and are more obvious, manifestation-wise. Hence, the three activities of the nervous system in this group are not only structurally but also functionally and manifestation-wise different from those of the biochemical system in Groups II–IV. Lastly, since the nervous system is

responsible for the obvious three activities in animals in this group, the obvious three activities and the mind of the obvious three activities in this group are associated with the nervous system. Hence, this kind of mind differs from those in the four groups discussed earlier and, as we will see, from that in the next group.

The final point to be noted for this group is that the three activities performed by the elementary physical system and those by the biochemical system also exist in this group because entities in this group, like all other physical entities, are basically composed of elementary particles and because cells, tissues, and organs compose entities in this group. Thus, the kind of mind associated with the elementary physical system and that associated with the biochemical system also exist in this group. Hence, three kinds of minds coexist in this group. This will be discussed in general again later.

Group VI: non-living things that are computerized (computers, robots, and other computerized machines)

Because entities in this group are non-living things, it may seem impossible for minds, like the ones we think exist in people, to exist in them. Nevertheless, if we use the word mind in a broader sense as stated at the end of Section D1.1, *a non-material entity that evidently executes the three activities*, we will see that they can have some kind of mind existing in them. This is because they do exhibit all the three activities evidently, at least in a behavioral sense. That is, they can *a) sense* (see, hear, or receive in other ways) signals via their various sensors (camera, microphone, mouse/keyboard, radiation sensor, chemical sensor, etc.), *b) act on* (analyze, integrate, store, retrieve, synthesize, etc.) signals resulting in complex activities that can be considered to be evaluating, planning, memorizing, recalling, decision making, etc., and *c) send* signals to their various parts (speaker, monitor, printer, hard drive, robotic arms/legs, etc.) to control the functions of those parts to respond to stimuli (such as by sending out sounds, displaying pictures, printing out texts, storing information, working, etc.). Obviously, these three kinds of signal processing can readily be considered the three activities because, manifestation-wise, these activities are obvious and familiar to us.

Because things in this group evidently exhibit activities that can be considered as the three activities, it is very possible that there exists a non-material entity that evidently executes the three activities, or a mind, in each of them. The kind of mind in this group can be the mind in the ordinary sense that general people think of because the manifestations of its three activities are obvious and are those that general people are familiar with and recognize in everyday life.

In this group, the signal processing of the obvious three activities is operated by the electronic system, which utilizes electronic circuits and signaling. Obviously, this kind of signaling is different from that of the nervous system in Group V. Operationally, the electronic system uses digital electronic signals of 0 and 1 bits (in the form of bit coding)

and primarily processes data sequentially, with a limited number of parallel processing elements, while the nervous system uses analog signals of action potentials, quantal neurotransmitter releases, and postsynaptic potentials [118–123] (in the form of frequency, temporal, population, and other types of coding) [124–145], and processes information both sequentially and in parallel, with an uncountable number of parallel processing components. Structurally, the electronic system is silicon-based, whereas the nervous system is carbon-based. Thus, the physical machinery that executes the obvious three activities in this group is different from that in Group V. Clearly, it is also different from that in Groups I–IV. Lastly, since the electronic system is responsible for the obvious three activities in this group, the obvious three activities and the mind of the obvious three activities in this group are associated with the electronic system. Therefore, this kind of mind differs from those in all other groups.

Finally, it is important to note that the three activities performed by the elementary physical system also exist in this group because the entities in this group, like all other physical entities, are basically composed of elementary particles. Thus, the kind of mind associated with the elementary physical system also exists in this group. Hence, two kinds of minds coexist in this group. This will be discussed in general below.

In conclusion, because all things in this universe can be considered to exhibit the three activities evidently, it is possible that there exists a non-material entity that evidently executes the three activities—the mind—in all of them. However, because the three activities in these various groups differ in at least three major aspects (please see Table 1), the minds of these various groups may be of different kinds, not just one single kind.

Table 1. The three activities in various groups

Group	Manifestations	Mainly for	Most evident system
I	in a technical sense	each component	the basic physical system
II	not obvious	each individual cell	the biochemical system
III	not obvious	each cell, tissue, organ	the biochemical system
IV	not obvious	each cell, tissue, organ	the biochemical system
V	obvious	the whole entity	the nervous system
VI	obvious	the whole entity	the electronic system

Groups I—non-computerized, non-living things, II—unicellular organisms, III—multicellular organisms without a nervous system, IV—parts of multicellular organisms, V—animals with a nervous system, and VI—computerized non-living things

First, except for Groups V and VI, the three activities are not obvious and are not activities of the mind in the ordinary sense. Second, except for Groups V and VI and for each elementary particle in Group I, these activities are mainly for individual parts (cells, tissues, organs, or portions of the entity), not for the whole entity. Third, the most evident three activities in each group are associated with different physical systems: the

elementary or basic physical system in Group I, the biochemical system in Groups II–IV, the nervous or neural system in Group V, and the electronic system in Group VI. Therefore, based on these characteristic differences, it can be logically argued that there exist not one but several kinds of minds—elementary, biochemical, neural, and electronic.

Moreover, different kinds of minds can coexist in a single entity in layers (please see Table 2). It seems that the kind of mind in Group I, the elementary mind, associated with the elementary or basic physical system, is the most basic and exists in the first layer of all things because all things are composed of elementary particles and the basic physical system operates in every physical entity.

Table 2. The mind in each layer

Group	The 1 st layer	The 2 nd layer	The 3 rd layer
I	The elementary mind	-	-
II	The elementary mind	The biochemical mind	-
III	The elementary mind	The biochemical mind	-
IV	The elementary mind	The biochemical mind	-
V	The elementary mind	The biochemical mind	The neural mind
VI	The elementary mind	The electronic mind	-

Groups I—non-computerized, non-living things, II—unicellular organisms, III—multicellular organisms without a nervous system, IV—parts of multicellular organisms, V—animals with a nervous system, and VI—computerized non-living things

Later, another kind of mind, the biochemical mind, associated with the biochemical system, evolved in Group II and subsequently in Groups III and IV, overlaying the elementary mind. Afterward, yet another kind of mind, the nervous system or neural mind, associated with the nervous system, evolved in Group V to exist in the highest layer, overlaying the elementary and biochemical minds. The latest development is the artificial kind of mind, the electronic mind in Group VI, associated with the electronic system, which is invented by humans and overlays the elementary mind.

It is important to note that the above classification is a simplified one. Its purpose is to categorize things into easily understandable groups. In reality, similar to the classification of other complex systems, such as living things, no absolute boundaries exist between systems. For example, no definite lines separate the basic physical, basic chemical, complex chemical, biochemical (which supports life in general), pre-nervous (which supports pre-nervous system animals: Trichoplax, sponges, and mesozoans), and nervous systems. Nevertheless, the classification helps us appreciate the possible existence of a continuous mind spectrum as well as its several distinct mind forms, associated with different physical systems, along the spectrum and guides us in the attempt to solve the questions about the mind as follows:

D1.3 The definition of the mind

Before we go on to set up the definition of the mind, let us take note of one fact. From the preceding discussions, we can see that a non-material entity that evidently executes the three activities, the mind, possibly exists in all physical entities. However, we cannot be certain that this is true. Except for one's self, one cannot be certain that there is the mind in other things.¹ Nevertheless, it is scientifically better to accept the possibility that there is the mind in other physical entities and investigate this possibility rather than deny it and not investigate it at all. Therefore, the author presumes that this possibility is viable, and this theory is based on the premise that there is the mind in physical entities other than humans.

Granted that there is a mind in each physical entity, we still have to face the problem that their minds may not be the same because of the differences discussed in the previous section. Questions about the mind, such as what the mind is, why and how it occurs, what its important phenomena—qualia and consciousness—are, and why and how they occur, are some of the most difficult. As there may be different answers for different kinds of minds, investigating a large, heterogeneous group of minds to find definitive answers for all of them in one attempt is likely to be complicated and unsuccessful. Hence, this theory, which is a basic theory, chooses to investigate only one homogeneous group. The group chosen is the kind of mind in **Group V—animals with a nervous system (humans and other animals with a nervous system)**—because it is the kind of mind that we think of most when the word “mind” comes up, that we are most familiar with, and that we have been wondering about for a very long time. This theory will attempt to answer what this kind of mind is physically and ontologically, why and how it occurs, and other related questions. Hopefully, the answers found by this theory for this kind of mind will provide a basis for more advanced theories to cover other kinds of minds and, ultimately, for a general theory of the mind that will cover all kinds of minds completely.

Therefore, based on a) the characteristics of the mind in general, as discussed in Sections D1.1 and D1.2, b) the additional, important fact that, in an animal with a nervous system, the mind is the sole non-material entity that can execute the three activities that include the highest-level activities in the animal for that whole animal, and c) the constraint discussed in the above paragraph, this theory will set up the working definition for the kind of mind that this theory will investigate as follows:

¹ *However, if one believes that nature is regular and consistent ... and elegant, one should believe that, at least, there are minds in other people and animals with a nervous system. The reason: If the reader or author, which is an animal with a nervous system and exhibits the three activities distinctly, has a non-material entity that performs the three activities—a mind—inside, other people and other animals with the same characteristics should have minds within them as well.*

Definition: The mind is a non-material entity that exists in an animal with a nervous system and that can evidently execute the three activities, including the highest-level ones of that animal, for the whole animal.

Specifically, the three activities are

- i. sensing signals from outside the body (such as light, sound, and tactile stimuli), from its own body parts (such as proprioceptive stimuli from joints, vestibular stimuli from vestibular organs, and pain from internal organs), and from within its mental self (such as emotions, thoughts, and memories),
- ii. acting on signals (such as integrating, storing, and retrieving), resulting in various mental processes, and
- iii. sending signals between its mental parts (such as between the sensory perception, consciousness, and emotion parts) and to the effectors of its body (striated muscles and smooth muscles, glands, and other specialized cells) to control its own body functions and respond to stimuli.

If the mind can execute all the three activities completely, it is considered a complete mind. If the mind can execute them only partially because the animal is still in a developing stage, such as the fetal stage, it is considered an immature mind. If the mind can do so only partially because the animal is sleeping, suppressed by a pharmacologic or toxic agent, or affected by a pathologic condition, such as a cerebral concussion, brain tumor, or stroke, it is considered a partially functioning mind. Although the mind can exist in various forms with varying degrees of completeness in executing the three activities, all forms are basically the same. That is, all are non-material entities that exist in animals with a nervous system and that can evidently execute the three activities, including the highest-level ones in their conditions, for the whole animals.

It should also be noted that when the brain of an animal is cut off, its body, limbs, and other parts can still perform the three activities (sensing, operating, and sending signals) for some time before all those parts die. In this case, a non-material entity that is left in these parts and can still perform the three activities is not the mind because it cannot execute the three activities at the highest level of that animal in all conditions, normal and abnormal; it is considered to be only part of a complete mind.

Finally, to recap in plain language, the mind that this theory investigates is the non-material entity that exists in us—the reader, the author, other people, and other animals with a nervous system—and can evidently execute the three activities (sensing, operating, and sending signals), including the highest-level ones, for each of us as a whole. This theory attempts to determine what this entity physically and ontologically is and why and how it occurs, together with answers to other associated questions.

D2. Brain

In this theory, the term “brain” refers to *a material organ that can evidently execute the three activities, including the highest-level ones of that animal, for the whole animal*. Structurally, it is *composed of material components* (mainly neural, but also vascular, connective, and other tissues) *and all their physical activities* (chemical, electrical, magnetic, etc.). Any non-material entity that may coexist with this organ, such as, theoretically, the mind or soul, is not part of the brain by this definition.

D3. Mental Process and Mental Phenomenon

In this theory, a mental process is *a mind’s component that performs any of the three activities*, and its product is called *a mental process phenomenon* or, in short, *a mental phenomenon*. For example, the visual-perception mental process is a mental process that perceives an image from visual stimuli, and its product—an image in the mind or a mental image—is its mental phenomenon; the emotion-generation mental process is a mental process that generates an emotion, and its product—an emotion—is its mental phenomenon, and the thought-formation mental process is a mental process that forms a thought, and its product—a thought—is its mental phenomenon.

A mental process can be *a conscious mental process* or *an unconscious mental process* [7,70,146–154], depending on whether the mind can experience *what the mental process’s mental phenomenon is like* or not [9,17,27–29,155]; if the mind can, then it is a conscious mental process; if not, then it is an unconscious mental process. For example, the final-stage visual-perception mental process is a conscious mental process because the mind can experience what its mental phenomenon (e.g., red in the mind) is like (e.g., we can experience what the red in the mind is like), whereas all early-stage visual-perception mental processes are unconscious mental processes because the mind cannot experience what their mental phenomena are like (e.g., we cannot experience what the mental phenomena of red perception in those early stages are like). This will be discussed in detail in Chapters 3 to 7.

D4. Neural Circuit

A neural circuit is *a group of neurons that are connected in a specific pattern* to perform the neural circuit’s principal function, which is *to process signals for a certain operation* [156–164], such as perceiving visual signals to form an image, integrating various signals to form a decision, or synthesizing signals to control a motor movement. Anatomically, a normal neural circuit is usually a complex, 3-dimensional circuit and always has connections to other neural circuits and sometimes to its sensor or effector so that it can receive signals from and send signals to them. A neural circuit is not a multifunctional circuit that performs various neural functions alternately. Instead, each neural circuit typically performs only one function [156,163,160,165], such as creating a

visual image, forming a decision, or generating a motor command. These function-specific neural circuits reside separately in various specific brain areas, such as visual-perception neural circuits in the visual and visual association cortices, emotion-generation neural circuits in the amygdala, hippocampal formation, limbic cortex, and some neighboring areas, and thought-formation neural circuits in the frontal and nearby cortices [165–180]. Currently, more than one hundred distinct functional brain areas have been identified using various methods [176,178,179,181].

However, a neural circuit may not be just a single group of locally connected neurons but may be a network of scattered, connected groups of neurons [160,164]. This is especially true for complex neural circuits that perform complicated functions, such as the neural circuits of *the central-executive network* (which operates attention- and cognition-demanding tasks) [161,182,183], *the salience network* (which recognizes the most relevant stimuli among various stimuli) [161,182–186], and *the default mode network* (which functions as the baseline state when the mind is not engaging in externally oriented tasks or as the internal mentation state when the mind is engaging in internally oriented tasks, such as retrieval of autobiographical memory, envisioning the future, or self-reflection) [161,183,184,185–205]—all these complex neural circuits consist of several neuron groups in various separate areas linked together. One of the most important neural circuits is the consciousness neural circuit, which is also a complex neural circuit; it functions for consciousness and will be discussed in detail in Chapter 7.

D5. Neural Process

A neural process is *the signal-processing process of a neural circuit*. A neural process is the principal process of a neural circuit because it processes the signals in the neural circuit to perform a specific operation. However, the neural process is not the only process in a neural circuit. A neural circuit has two other major processes: the metabolic process and the structural maintenance process (of membranes, organelles, cytoskeletons, etc.).

Two types of signal-processing processes occur in neural circuits. The first is a fast signal-processing process, which processes electrical or chemical signals that are transmitted through electrical or chemical synapses and then transfers the processed signals to other synapses on other neurons for further processing. This signal-processing process proceeds rapidly on a timescale of milliseconds (ms). The second is a slow signal-processing process, which modifies the neural circuit's structure and performance (e.g., by modifying the structures of neural membranes, receptors, and synapses to change their sensitivity and responses) to store information from the passing signals for the formation of long-term memory, skill, personality, etc. [206–211]. This signal-processing process may take much longer time than the first type; it can last from milliseconds to years [118,208].

The neural process is not instantaneous. Even for a fast signal-processing process, it takes some milliseconds to complete the process in each neural circuit [118,212–215]. For example, after signals of an image reach the primary visual cortex, they are processed through successive visual-perception processing areas, taking about 10 ms of processing in each area so that the visual perception of this image is formed in about 100–120 ms [215–220], the whole brain is updated about the new image within 100–200 ms (depending on the species and brain size) [76], and a conscious visual percept is formed in about 150–400 ms from the signal onset [213,221,222].

The result of the processing is the product that the neural circuit and process function for. For example, the result of visual-perception processing—an image—is the product that the visual-perception neural circuit and process function for. One neural process that is of paramount importance is the neural process whose result is consciousness. This neural process is the signal-processing process of the consciousness neural circuit and is called the consciousness neural process. Like the consciousness neural circuit, a more detailed discussion is provided in Chapter 7.

D6. Signaling Pattern

A signaling pattern (SP) is *the pattern of signaling that a neural circuit sends to another neural circuit to convey information*.

An SP is a dynamic, 3-dimensional pattern of neural signaling. Neural circuits can encode their information in SPs by encoding electrical spikes that are sent along the axons [118,119,129,206] (or the dendrites in some cases [223–228]) to synaptic or neuromuscular junctions in the form of frequency, temporal, population, latency, rank, and other types of coding [124–145]. Since a neural circuit communicates its information to others via electrical signaling, electrochemical signaling, or both in the form of SPs, an SP that the neural circuit sends to another circuit must be the information that is to be sent [129,132,141,206]. However, for a receiving neural circuit to be able to distinguish a particular piece of information, the SP for that particular piece of information must be unique—different from all other SPs for other information pieces [132]. For example, when the visual-perception neural circuit sends an SP to a certain neural circuit, the SP for the visual perception of the letter “A” must be unique—different from the SPs for that of the letter “B,” a red color, a house image, and so on.

SPs are very important because every neural circuit receives information from other neural circuits and its sensors and sends information to other neural circuits and its effectors in the form of SPs. Thus, every neural circuit is affected by other neural circuits' and its sensors' SPs, and it affects other neural circuits and its effectors by its SPs. The fact that SPs are the only signals that neural processes can read helps us answer the problems of what qualia and consciousness are. This matter will be discussed in detail in Chapters 3 to 7.

D7. Signaling State

A signaling state (SS) is *the pattern of signaling of a whole neural circuit*, with signals circulating in the circuit in a particular pattern at a certain moment.

In the same way that an SP is the information that a neural circuit sends to other neural circuits, an SS is the information that is in the neural circuit at that moment. For example, after the primary visual-perception neural circuit has received early-stage visual signals of a house from the lateral geniculate nuclei, it will have the SS—signals circulating in its circuit in a particular pattern—that is *the information about the early-stage visual perception of the house*; then, after the final visual-perception neural circuit has finished the process of perceiving the vision of the house, it will have the SS—signals circulating in its circuit in another pattern—that is *the information about the final visual perception of the house* (i.e., the visual image that we see in our mind).

Similar to SPs, SSs are important because they contain information that exists in the neural circuits at a particular moment. Most importantly, we will see that the SS of a certain neural circuit, the consciousness neural circuit, is deeply connected to the occurrence and function of consciousness. This connection will be discussed in detail in Chapter 7.

D8. Information

Information is an important entity; however, at present, there is no established standard definition for it. Therefore, when people talk about information, they may refer to different things and talk past each other [229–237]. Thus, this theory sets up a working definition for this term to avoid misunderstandings. The definition that this theory uses is applicable to situations in ordinary daily life; that is, information is *a non-material thing that is transferable*.² For example, the information on this page is a non-material thing that is transferable from the author to this page and from this page to the reader.

Other important characteristics of this type of information are that a) it consists of content, b) it is embodied in a physical object, which is called the carrier of the information, and c) ontologically, it is the pattern of its carrier [234,237,238]. For example, the information on this page consists of content that is about the definition of the term information; it is embodied in dots on a sheet of paper or pixels on an electronic screen; ontologically, it is the pattern of the dots or pixels that appears as the text that the reader is reading. Here, it is important to note that it is the non-material pattern, not the material dots or pixels per se, that is the information. If the material dots or pixels change (such as their brightness, colors, sizes, or their composing materials are changed) but the pattern remains the same, the information remains the same; on the contrary, if

² The detailed derivation of this definition, together with related discussions, is in Extra Chapter I: Information.

the material dots or pixels remain the same but the pattern changes (such as changes into patterns of other texts), the information changes.

Regarding the nervous system, which is the principal area investigated by this theory, typical examples are visual and auditory information about the outside world:

- Visual information about the outside world is non-material and transferable from outside-world objects to the light waves reflected from the objects and then to an animal's visual and other processing systems. It consists of content: visual characteristics—color, brightness, shape, dimension, movement, etc.—of the objects. It is first embodied in the objects' surfaces, then in the light waves, and then in the neural signals of the animal's visual and other processing systems. This visual information is, first, the pattern of the object's surface, then, the pattern of the light waves, and finally, the patterns of neural signaling in the animal's visual and other processing systems.

- Sound information about the outside world is non-material and transferable from outside-world objects to the air surrounding the objects and then to an animal's auditory and other processing systems. It consists of content: sound characteristics—pitch, timbre, loudness, formant, attack, etc.—of the vibrations of the objects. It is first embodied in the vibrations of objects, then in the air waves (sound waves) from the objects, and then in the neural signals of the animal's auditory and other processing systems. This auditory information is, first, the pattern of the object's vibrations, then, the pattern of the air waves, and finally, the patterns of neural signaling in the animal's auditory and other processing systems.

Because information, by this definition, consists of content for information receivers to interpret, it has meaning and is semantic information [164,229–231,239,240]. It is essential to note that the meaning of a piece of information is relative, not absolute. That is, the meaning of a piece of information varies, depending not only on the pattern of the physical carrier but also on the receiver and context in which the information is transferred [233,241]. A particular piece of information usually means a specific thing to a certain receiver in a certain context but means different things, incomprehensible things, or nothing to other receivers or in different contexts. For example, the information embodied in this dot/pixel pattern **consciousness** means consciousness to those who know English but means gibberish or practically nothing to those who do not; the information embodied in this pattern 头脑 means mind or brain to those who understand Chinese but means gibberish or practically nothing to those who do not. Regarding the context of information transfer, an example is that, to people who know the convention of clock chiming, the information embodied in the three chimes of a striking clock's bell means, in the morning, that the time is 03:00, but means, in the afternoon, that it is 15:00. Likewise, information of SPs in the human optic nerve means images in the outside world to the human visual nervous system but means gibberish or nothing to other parts of the nervous system and everything else (e.g., a television set, a DVD player, and a current computer—all of which cannot decode information in the human optic nerve's SPs, even if we could somehow feed the SPs to them).

Introduction and Definitions

The paramount importance of the meaning of information can be briefly glimpsed from the following fact: If the information of a certain neural SP means “what it is like to see a red color” to some neural process, then when that neural process reads the information in the SP, “what it is like to see a red color” will naturally and inevitably appear in that neural process, and thus in the brain. This is how phenomenal qualia and consciousness can occur in physical systems. This important matter is discussed in detail in Chapters 3 to 7.

Chapter 1

Theorem I: The Mind Coexists with the Brain

What is the mind? Specifically, what is it physically and ontologically? This question is one of the most important in our lives. Still, we cannot definitively answer it. Various other questions about the mind also exist and remain unanswered. One of them that is not only fascinating but also fundamental is whether the mind is an entity that can exist and function separately from the brain. For many people and in many religions, the answer is affirmative. This belief has led to popular stories about the mind as an entity that can exist, wander, and carry out various activities outside the brain. Obviously, pictures, novels, and movies portraying the mind in this way abound. However, in the scientific world, the answer is still inconclusive. Because this question is fundamental and underlies other mysteries of the mind, this theory attempts to solve it first in this chapter. The problem of what the mind is physically and ontologically, which is more difficult to determine, is addressed in the next chapter.

Even though the mind has been studied for a very long time, probably first by pre-historic thinkers and later by religious practitioners (priests, monks, shamans, etc.), philosophers, and, lately, neuroscientists and scientists in related fields, the above puzzles remain unsolved. One possible reason for this lack of resolution is that certain properties of the mind, specifically physical properties, have not been comprehensively examined. In the past, the exploration of these conundrums was hindered by a dearth of tangible, empirical evidence, causing investigators to focus primarily on studying the functional attributes of the mind through personal observations. As a result of this approach, they discovered a range of distinct characteristics associated with the mind, including its private nature, subjectivity, indescribable qualities, representational capacity, and intentional disposition, as well as its possession of propositional content and qualitative properties [1–10]. However, these properties are related to the mind's functions rather than the outside physical world and thus do not yield essential clues about the mind's physical nature. Thankfully, since the past few decades, empirical, physical evidence has become available, and some mental phenomena such as qualia and consciousness have been investigated increasingly in terms of their physical properties. For instance, some of the physical properties of qualia have been found to be related to information processing, neural processing (especially in the resonant state), and neural activity patterns [11–16]. Regarding consciousness, some of its proposed physical properties are as follows: being integrated and constructed by the brain [17], involving the thalamocortical core and re-entrant signaling, having widespread brain effects, having informative content [8,18], and being related to integrated information [19–21]. Although many investigations of these

physical properties have led researchers to formulate theories about the physical nature of qualia and consciousness, resulting in many theories on various aspects of these two entities [8,11–15,17–23], they neither covered other important physical properties nor systemically investigated them for the mind as a whole. They did not definitively answer whether the mind is a physically separate entity from the brain and what the mind physically and ontologically is, either. Therefore, to resolve these problems, it is necessary to comprehensively examine the mind's physical properties, which are directly related to the physical world, particularly those that have not yet been thoroughly examined.

This chapter scrutinizes physical properties of the mind to answer the question of whether it exists and functions separately from the brain as follows:

1.1 Physical Properties of the Mind and Mental Processes

If the mind and mental processes are defined as stated in Sections D1 and D3, the previous chapter, we find that they are related to the outer physical world through several properties. Ten of these, which this theory finds essential in revealing the physical nature of the mind and mental processes, are as follows:

Physical properties of the mind and mental process (PM)

PM1. Defining physical properties

PM1.1 Their nature is non-material.

PM1.2 Their activities are signal processing.

PM2. Additional physical properties

PM2.1 Their existence is concurrent with their neural processes’.

PM2.2 Their locations are the same as their neural processes’.

PM2.3 Their information is the same as their neural processes’.

PM2.4 Their abilities are the same as their neural processes’.

PM2.5 Their capacities are the same as their neural processes’.

PM2.6 Their chronological aspects are the same as their neural processes’.

PM2.7 Their changes are the same as their neural processes’.

PM2.8 Their activities are associated with electromagnetic activities.

PM1. Defining physical properties

Defining physical properties are physical properties that we believe the mind and mental processes should have and that are used to define them (Sections D1 and D3, the previous chapter). They are as follows:

PM1.1 Their nature is non-material.

By definition, the mind and its mental processes are non-material entities. When we evaluate this property, we find that it is valid to our intention because we never find any material entity that is called or should be called mind or a mental process.

PM1.2 Their activities are signal processing.

As the definition requires that the mind and its mental processes can execute “*the three activities*,” which are sensing, operating, and sending signals from both the outside and inside of the mind (resulting in various mental activities, such as perceiving visual images, thinking of several things, and controlling motor movements—see Section D1.3, the previous chapter), the activities of the mind and mental processes must be signal-processing. When we evaluate this property, we find that it is also valid to our intention because we never find any entity not sensing, operating, and sending signals that is called or should be called mind or a mental process.

PM2. Additional physical properties

Additional physical properties are physical properties that the mind and mental processes possess in addition to their defining physical properties. They are as follows:

PM2.1 Their existence is concurrent with their neural processes’.

It is universally observable that, in animals with a nervous system, the existence of a mental process is concurrent with the existence of a certain neural process, which this theory calls *the mental process’s neural process* (or, in short, *its neural process*). For example, the existence of the visual-perception, emotion-generation, and thought-formation mental processes are found to be concurrent with the existence of the visual-perception, emotion-generation, and thought-formation neural processes, respectively—these mental processes have never been found to exist without the concurrent existence of their respective neural processes.

There is a large amount of clinical and experimental evidence for this relationship. For example, the visual-perception mental process occurs and exists concurrently with its neural process, which is the visual-perception neural process. The visual-perception mental process occurs and continues to exist only when the visual-perception neural process occurs and continues to exist (such as when visual stimuli arrive at and get processed in the visual-perception neural process, when the ischemic visual-perception neural process recovers from ischemia after blood reperfusion occurs [such as in the case of a transient ischemic attack], or when the visual-perception neural process is stimulated to function by migraine aura activity, epileptic activity, or electrical [24–32] or magnetic stimulation [33–46]). Conversely, the visual-perception mental process ceases to exist when its neural process ceases to exist (such as when there is a cessation of its blood supply, there is an injury to it, or its function is interfered with by magnetic stimulation

[33,34,37–42,45,46]). The visual-perception mental process has never been found to occur or exist alone or with anything other than its neural process. These associations can be scientifically verified³ and are true for all other mental processes. Thus, mental processes' existence is concurrent with their neural processes' existence. Because the mind is a composite of mental processes, including the highest-level mental processes, its existence is concurrent with that of a composite of neural processes, including the highest-level neural processes. Therefore, in the maximal case, the mind's existence is concurrent with the whole nervous system's existence. However, in the minimal case, its existence is concurrent with the brain's existence because the minimal organ that can fulfill the requirement of having the highest-level neural processes is the brain.

PM2.2 Their locations are the same as their neural processes'.

The mind has a definite spatial location. There has long been an unfounded belief among many people, including some philosophers, that the mind does not have a definite location in space [2]. However, this belief has not been scientifically substantiated. In contrast, at present, there is overwhelming evidence that the mind has a definite location. It always occurs in the brain. It has never been found elsewhere; that is, it has never been found in any body parts other than the brain (such as the heart, abdomen, hand, etc.) or outside the body. This is evident from the fact that these body parts can be injured, removed, or replaced without injuring, removing, or replacing the mind; only some localized effects resulting from injuring, removing, or replacing a body part, such as loss of sensation or motor command of that part, will occur. Similarly, everything outside the body can be damaged, destroyed, or replaced without affecting the mind. In contrast, if the brain is disturbed or destroyed, the mind will be simultaneously disturbed or destroyed. If one wants to find, examine, monitor, manipulate, or destroy the mind, one has to find, examine, monitor, manipulate, or destroy the brain. Hence, the mind has a definite location in space: in the brain.

Similarly, mental processes have definite spatial locations. They always occur in the nervous system (the brain, spinal cord, and peripheral, autonomic, and enteric nervous systems). They have never been found elsewhere, neither in body parts without parts of the nervous system (such as blood, hair shaft, and nail plate) nor in something outside the body. This is evident from the fact that such a body part can be affected, removed, or replaced without affecting, removing, or replacing mental processes. Likewise, everything outside the body can be damaged, destroyed, or replaced without affecting

³ *That a neural process starts, continues, or stops functioning can be confirmed by techniques such as functional magnetic resonance imaging (fMRI) [47–55], magnetoencephalography (MEG) [50,56–60], electroencephalography (EEG) [50,51,61–66], electrocorticography (ECoG) [67–82], stereoelectroencephalography [83–84], and single-unit recordings in the cerebral cortex [84–92], and that a corresponding mental process does the same can be confirmed by evaluating the patient or volunteer reports.*

mental processes. In contrast, if the nervous system is disturbed or destroyed, mental processes are simultaneously disturbed or destroyed. If one wants to find, examine, monitor, manipulate, or destroy mental processes, one has to find, examine, monitor, manipulate, or destroy the nervous system. Thus, mental processes have a definite location in space: in the nervous system.

Where do the mind and mental processes exist in the nervous system? They do not exist in the meninges, blood vessels, supporting connective tissue, or any other tissues of the nervous system other than the functioning neural circuits. This is evident from the fact that diseases such as pure meningitis, atherosclerosis of the nervous system blood vessels, and intracerebral calcification, which affect only tissues other than functioning neural circuits, do not affect the mind and mental processes. Also, mechanical effects on or electrical stimulation of these tissues without affecting functioning neural circuits do not affect the mind and mental processes, either. In contrast, electrical or magnetic stimulation, diseases, or pharmacological agents that selectively affect functioning neural circuits but do not affect other tissues affect the mind and mental processes. Therefore, the locations where the mind and mental processes reside must be functioning neural circuits. This is supported by abundant evidence from studies in clinical neurology and cognitive neuroscience, which have revealed that each specific mental process occurs in its specific neural circuit. For example, various mental processes for the visual identification of a face occur in various face perception areas, such as the occipital face area, fusiform face area, and ventral anterior temporal lobe, in which various facial identification neural circuits have been found [93–96]. Generally, this kind of location specificity is true for all mental processes. Therefore, mental processes are located at the locations of their functioning neural circuits.

Where do the mind and mental processes reside in the functioning neural circuits? A functioning neural circuit comprises signal processing, metabolic, and structural maintenance (of membranes, organelles, cytoskeleton, etc.) parts. Because the mind and mental processes perform signal-processing functions (property PM1.2), it is unlikely that they reside in the metabolic or the structural maintenance parts because these parts cannot receive, operate, and send specific signals (signals that convey specific information, not nonspecific information that may exist in heat from metabolism and minute vibrations from the structural modification processes) between neural circuits. The only part that can process specific signals in which the mind and mental processes most likely reside is the signal-processing part. This is supported by the fact that anything that affects the signal-processing part but does not affect the other parts, such as electrical stimulation, magnetic stimulation, or pharmacological agents that selectively affect the signal-processing part, can affect the mind and mental processes. Therefore, the locations where the mind and mental processes exist are specifically the signal-processing parts of their functioning neural circuits: the neural processes.

At this point, some may oppose this conclusion by citing phenomena such as near-death and out-of-body experiences [97–108] as evidence that the mind or mental processes can exist outside the body and brain, and thus outside the neural processes. However, it has never been definitively established that the mind and mental processes exist outside the body and brain during these phenomena, even though they have been studied for more than a hundred years [109,110]. Also, similar phenomena have recently been documented to occur not only in epilepsy, migraine, depersonalization-derealization disorder, and several other non-life-threatening events but also during electrical brain stimulation and transcranial magnetic stimulation of the parietal, temporo-parietal junction, or temporo-occipital cortex [111–121]. Therefore, such extraordinary phenomena can occur because of abnormalities or interference in neural process functions, which always occur in near-death situations. Interestingly, brief surges of electroencephalographic activities at the time of death have been reported [122–125], and a new phenomenon called cardiopulmonary resuscitation-induced consciousness (CPRIC) [126–130] has been recently recognized. Although this matter is still controversial [131], some think that near-death and out-of-body experiences may be part of the spectrum of this phenomenon. In addition, several plausible neural-based explanations of near-death and out-of-body experiences have been proposed [120–124,132–134]. Hence, this theory concludes that there is no definite evidence that the mind can exist outside the brain or that mental processes can exist outside neural processes.

In summary, if one wants to find, examine, monitor, manipulate, or destroy the mind or mental processes, then one has to find, examine, monitor, manipulate, or destroy the brain or its neural processes. Thus, for all intents and purposes, the mind's and mental processes' locations are those of the brain and their neural processes, respectively.

Definition: The outside world and the external world.

“The outside world” and “the external world” are the terms that are used frequently in this theory. They mean the world that is, from the mind's point of view, “outside” or “external.” *It includes everything except the mind and the place where it resides* (the neural processes). Thus, not only all things outside the brain but also all the non-neural process parts of the brain, such as the cerebral blood vessels and meninges, are included in the outside or external world.

PM2.3 Their information is the same as their neural processes’.

A mental process's information, which manifests itself as the details of the mental process's product, such as the color, brightness, and location of every point in a mental image; the pitch, timbre, and loudness of a perceived sound; or the details of a recalled past event, is the same information as its neural process's information. There can be no mental process's information that is not the same as its neural process's, because the

mental process does not have information sources other than its neural process. If this is not the case, then there must be some mental process's information not the same as its neural process's manifesting in the mental process's product. For example, there must be some extra image occurring in the perceived vision even if the object of that extra image is not seen by the subject and thus has no information in the neural process (e.g., there must be people or other extra objects in front of the house in the perceived vision, even if one looks at a bare house without people or other extra objects in front of it), or there must be some of the mental process's information left manifesting even after the neural process stops functioning (e.g., there must be some part of the perceived vision left occurring after the eyes have been closed, after there is no blood supply to the occipital lobes, or after the occipital lobes have been destroyed). However, such cases never happen. By contrast, whenever information in the neural process changes or disappears, the information in the mental process changes or disappears accordingly and simultaneously. For example, when people gather in front of the bare house in the previous example, there will be additional information about those people in the visual perception neural process, and the mental image will inevitably consist of an image of those people. On the contrary, when there is a lesion in the ventral, caudomedial occipitotemporal, or ventromedial occipital cortex, which functions to create color information for images in the opposite visual field, the neural process's perceived images in the opposite visual field will inescapably lack color information, resulting in achromatopsia (color blindness) in that visual field [135–138], and the mental images in that visual field will unavoidably be devoid of colors.

Thus, mental processes' information is the same as their neural processes'.

PM2.4 Their abilities are the same as their neural processes'.

The abilities of the mind and mental processes to sense something in the outside world, perform mental operations, and affect things in the outside world are the same as those of their neural processes. There can be no mind's and mental processes' abilities that are not the same as their neural processes'.

A. To sense things in the external world, the mind and mental processes do not have whatever sensing abilities they want; their sensing abilities must only be the same as their neural processes'. For example, in humans, the mind and mental processes have the abilities to sense only visual, auditory, olfactory, gustatory, somatosensory, proprioceptive, vestibular, and some internal-organ stimuli because human neural processes have sensing abilities only of these modalities. Whatever sensing abilities the neural processes do not have, the mind and mental processes do not have either. For example, because human neural processes do not have the ability to sense magnetic stimuli, which can create magnetoreception in some animals, such as birds, bats, bees, and sharks [139–141], or to sense electrical stimuli in a way that creates electroreception or electrolocation, as

found in certain fish species like electric fish, which use this ability to navigate or locate prey [142–147], the human’s mind and mental processes do not have the abilities to sense these stimuli either, even if they try to.

In addition, the mind and mental processes do not have the ability to sense things by themselves but require the sensing ability of their neural processes. For example, to mentally see or hear anything in the external world, the mind and visual or auditory mental processes cannot see or hear anything by themselves but require the sensing ability of the visual or auditory neural processes (and the visual or auditory receptors and pathways), respectively. If these neural processes lose this ability and cannot function to see or hear (such as in the case of a stroke, tumor, or trauma), the mind and visual or auditory mental processes cannot see or hear anything, even if they try to.

It should be noted that, regarding phenomena of extraordinary sensory perception, such as extrasensory perception (ESP), telepathy, clairvoyance, “psi,” and parapsychological or paranormal phenomena, although there is literature supporting the existence of these phenomena [148–155], the evidence is still inconclusive. This is because the studies were not methodologically rigorous enough (according to current scientific standards) and required improvement [148,152,156,157]. Moreover, many studies and meta-analyses of these phenomena have not confirmed their existence [158–161]. This is despite approximately a century of investigation of these phenomena, sizable prizes offered in various countries worldwide [162,163], and undoubtedly immense fame for those who can prove these phenomena to be true. Because these phenomena seem to contradict the current physical laws, the mainstream scientific community still doubts the authenticity of these phenomena in a supernatural form [164]. Moreover, some investigators have recently shown that these phenomena are explicable by current physical laws [151,165] or psychological processes [166] or have correlates in the physical brain [154,167–169]. Hence, it is possible that these seemingly extraordinary phenomena are simply ordinary physical phenomena occurring in unusual ways.

However, it must be noted that, regarding the mental property being discussed in this subsection—the sensing abilities of mental processes are the same as those of their neural processes—this property does not preclude the existence of these extraordinary mental abilities. This property requires only that, if these extraordinary mental abilities exist, they not occur by themselves and be abilities of some neural processes. If they really exist, the scientific community has the duty to find their underlying physical mechanisms, whether they are already known or require new discoveries. In any case, if it is found that these extraordinary mental abilities are real and can occur independently without the functions of some neural processes, this property will be incorrect and must be removed from the list of physical properties of the mind and mental processes.

B. To operate mental functions, the mind and mental processes do not have whatever operating abilities they want; their operating abilities must only be the same as their neural processes'. Whatever operating abilities the neural processes do not have, the mind and mental processes do not have either. For example, because normal human neural processes do not have the ability to process signals at an arbitrary or unlimited speed, to turn off or on their whole processing operations at will, or to calculate the square roots of odd digits (3, 5, 7, etc.) by themselves, the human's mind and mental processes do not have the ability to think at arbitrary or unlimited speeds, to lose or become conscious at will, and to calculate the square roots of odd digits purely mentally, even if they try to.

In addition, the mind and mental processes do not have the ability to operate mental functions by themselves but require the operating ability of their neural processes. For example, to consciously perceive the image of a house, the visual perception mental process that creates the mental image of the house cannot relay this image to the consciousness mental process directly by itself but requires the operation of the visual perception neural process, the consciousness neural process, and their connections. If there is damage to any point of this neural operation (such as in the case of a stroke, tumor, or demyelinating disease), this mental operation cannot occur, and the conscious perception of the image of the house will not occur.

C. To affect things in the external world, the mind and mental processes do not have whatever affecting abilities they want; their affecting abilities must only be the same as their neural processes'. For example, in many animals, the abilities of the mind and mental processes to affect the outside world are limited to volitional motor movement (such as using hands, legs, and vocalizing organs), non-volitional motor movement (such as smooth muscle contractions and various motor and autonomic reflexes), secretion of hormones or other substances (such as pheromones, digestive enzymes, and poisons), and other means found in some animals⁴ because the animals' neural processes have only these affecting abilities. Whatever affecting abilities the neural processes do not have, the mind and mental processes do not have either. For example, because human neural processes cannot command the body to change its color or shape, produce and emit light, produce and discharge electricity, or perform extraordinary feats, such as commanding the body to levitate, teleport, or become transparent, the human's mind and mental processes cannot execute these deeds either, even if they try to. Even in its own body or itself, the mind can affect only what the neural processes can. Whatever the neural processes cannot affect, the mind cannot either, even if that thing is in its own body or itself. For example, the mind cannot, no matter how hard it tries, heal a body wound

⁴ Such as color changing in octopuses, chameleons, frogs, etc.; shape changing in some caterpillars, pufferfish, frogs, etc.; bioluminescence or production and emission of light in fireflies, comb jellies, deep sea fishes, etc.; and production and discharges of electricity in electric eels, electric catfish, electric rays, etc.

instantly, slow down or reverse aging processes in its body, or halt a dementing disease that affects the mind itself because no neural processes can do so.

In addition, the mind and mental processes do not have the ability to affect the outside world by themselves but require the affecting ability of their neural processes. For example, to affect anything in the external world with its hand, the mind cannot, by itself, command the hand to do anything but requires the affecting ability of the volitional motor neural processes to command the muscles of the hand. If the volitional motor neural processes lose this ability (such as in the case of a stroke, tumor, or degenerative disease), the mind cannot command the hand to do anything, even if it is its own hand.

It should be noted that, similar to the extraordinary sensory perception discussed in Section A, mental abilities that can affect the outside world in extraordinary ways, such as telekinesis (or psychokinesis) and spiritual and distant healing, have not yet been proved to be real despite hundreds of years of claims and practices. Studies of spiritual and distant healing are conflicting [170–173]. Those with positive results reported that the benefits were usually limited and short-term [174–176] and that the areas of improvement were mainly psychological, such as improvement in spiritual well-being and quality of life and reduction in pain, depression, anxiety, grief, and hopelessness [174–179]. Thus, spiritual and distant healing are not scientifically proven modes of medical therapy [170,171]. This contrasts with proven effective medical therapies (medication, surgery, radiosurgery, deep brain stimulation, magnetic stimulation, etc.), which have gained widespread acceptance and have become standard treatments in a matter of only years or decades after their introduction.

However, it must be observed that, regarding the mental property being discussed in this subsection—the affecting abilities of mental processes are those of their neural processes—this property does not preclude the existence of these extraordinary mental abilities. This property requires only that, if these extraordinary mental abilities exist, they not occur by themselves and be abilities of some neural processes. If they really exist, the scientific community has the duty to find their underlying physical mechanisms, whether they are already known or require new discoveries. In any case, if it is found that these extraordinary mental abilities are real and can occur independently without the functions of some neural processes, this property will be incorrect and must be removed from the list of physical properties of the mind and mental processes.

PM2.5 Their capacities are the same as their neural processes’.

The capacities of the mind and mental processes in sensing something in the outside world, performing mental operations, and affecting things in the outside world are the same as those of their neural processes. There can be no capacities of the mind and mental processes that are not the same as their neural processes’.

A. Regarding sensing things in the external world, the mind and mental processes do not have whatever sensing capacities they want; their sensing capacities must only be the same as their neural processes'. For example, the mind and mental processes can sense any specific sensation only in limited ranges (such as the limited frequency and amplitude ranges of the visible and audible spectra and the limited spatial range of the visual field) and with limited acuity (such as the limited acuity of vision, hearing, and fine-touch feeling) because the neural processes have the capacity to sense only in these limited ranges and with limited acuity. Whatever sensing capacities the neural processes do not have, the mind and mental processes do not have either. For example, because human neural processes do not have the capacity to sense light in the infrared or ultraviolet spectrum, at very low intensity, or outside of the visual field, the human mind cannot see things in infrared or ultraviolet light, cannot see things when it is too dark, and cannot see what is behind the back of its head, even if it wants to.

B. As for performing mental operations, the mind and mental processes do not have whatever operating capacities they want; their operating capacities must only be the same as their neural processes'. Whatever operating capacities the neural processes do not have, the mind and mental processes do not have either. For example, because human neural processes do not have the operating capacity to remember all the texts on a newspaper page in one second, to process everything that ten people say to them at the same time, and to solve ten mathematical equations simultaneously by themselves, the human mind does not have these operating capacities either, even if it wants to.

C. Respecting affecting things in the outside world, the mind and mental processes do not have whatever affecting capacities they want; their affecting capacities must only be the same as their neural processes'. Whatever affecting capacities neural processes do not have, the mind and mental processes do not have either. For example, because human neural processes do not have the capacities to command one hand to write a story while the other is drawing a complex picture, one foot is tapping every second, and the mouth is singing a song, the human mind does not have these affecting capacities either, even if it wants to.

Interestingly, extraordinary capacities that the general population does not have can be found in people with Savant syndrome, both autistic and acquired. For example, some savants can rapidly memorize thousands of books with subsequent comprehensive knowledge of geography, history, literature, etc.; some have accurate calendar-calculating abilities; some can recite the number π to 22,514 digits; also, some can solve mathematical problems in the blink of an eye [180–186]. These individuals have abnormalities in some brain areas, especially the left frontotemporal lobe. Acquired Savant syndrome can occur in patients with stroke, head injury, or even some degenerative disease that affects the left frontotemporal lobe. Transcranial magnetic stimulation that inhibits the function of this area can also elicit these kinds of unusual

capacities, albeit only transiently. Therefore, it is probable that lesions in the left frontotemporal lobe cause disinhibition of neural processes in other areas and enable them to function with extraordinary capacities [180–186]. Thus, when neural processes can perform functions with extraordinary capacities, the mind and mental processes can equally perform functions with extended capacities.

PM2.6 Their chronological aspects are the same as their neural processes’.

The mind’s and mental processes’ chronological aspects, that is, their starting time, processing rate, and ending time, are the same as their neural processes’.

When a stimulus enters the body, the mind and the related mental process do not start processing the stimulus’s signal immediately but only when the corresponding neural process starts doing so. For example, when our foot hits something hard, the mental process for processing dull, aching pain does not start processing the pain signal immediately, and we do not begin to feel the resulting dull, aching pain instantly but about some hundred milliseconds to a few seconds later (depending on several factors), when the “slow pain” processing center in the brain receives the pain signal and begins functioning.

A mental process’s processing rate is also the same as its neural process’s. When given a task to process, such as solving a problem or making a response to some stimulus, a mental process takes the same time as its neural process does to finish the task, not before or after. Also, when the neural process’s processing rate slows down from aging, diseases (such as hypothyroidism, Cushing syndrome, and some dementias), alcohol, or drugs (such as various sedatives), the mental process’s processing rate slows down similarly; it cannot maintain its normal processing rate.

A mental process’s ending time is the same as its neural process’s as well. When the neural process does not end its processing, the mental process cannot end its either. For example, when we look at a bright lamp and then close our eyes to see nothing, we will still keep seeing an afterimage even if we do not want to. The mental process can stop functioning (and the afterimage disappears) only when the neural process stops creating the afterimage.

(The above correlations between the chronological aspects of a mental and neural process can be demonstrated by various empirical investigations, such as fMRI, MEG, and ECoG.)

PM2.7 Their changes are the same as their neural processes’.

When neural processes change, the corresponding mental processes simultaneously and similarly change with their neural processes (both qualitatively and quantitatively) so that their changes are the same (match). For example, in an acute case, mental processes change instantly with their neural processes when a sudden head injury occurs, and the type (quality) and severity (quantity) of the mental processes’ changes match the type and

severity of the neural processes' injuries. In a subacute case of a brain tumor destroying the frontal lobe, the person's personality, intellect, and emotions change and worsen gradually, matching the type, severity, and chronology of the neural process destruction. In a chronic case of Alzheimer's disease, the patient's personality, intellect, memory, and language capabilities deteriorate gradually but relentlessly, matching the type, severity, and chronology of the inexorable neural-process degeneration.

This kind of matching change is also true in cases of electrical or magnetic stimulation and administration of psychoactive drugs. Whenever neural processes (such as visual, auditory, or somatic perception) are changed by electrical or magnetic stimulation, the corresponding mental processes (such as visual, auditory, or somatic perception) will change accordingly and simultaneously, and whenever psychoactive drugs (such as sedatives, anxiolytics, or psychedelics) affect neural processes, the corresponding mental processes will change accordingly and simultaneously. All these matching changes between neural and mental processes can be verified empirically.

It should be noted that, when their neural processes change, the mind and mental processes must change, even if they try not to. On the other hand, if their neural processes do not change, the mind and mental processes cannot change, even if they try to. For example, the mind cannot fall asleep, get out of a depressive or anxious state, change its behavior, understand difficult things, or attain spectacular sports skills at will because the involved neural processes cannot change to suit the mind's desire whenever the mind wishes.

Thus, the mind's and mental processes' changes match or are the same as their neural processes'.

PM2.8 Their activities are associated with electromagnetic activities.

Although the mind and mental processes are non-material entities, their activities are not physically traceless—they are associated with electromagnetic phenomena. Whenever and wherever there are the mind and mental processes, there are electromagnetic activities. Electrical activities can be recorded in various ways, such as electroencephalography (EEG) at the scalp, electrocorticography (ECoG) at the cortex using subdural or intracortical microelectrodes, stereoelectroencephalography in the brain tissue, and single-unit recordings in the cerebral cortex. Magnetic activities can be recorded using magnetoencephalography (MEG) outside the brain. Not only can these electromagnetic activities signify the presence of the mind and mental processes, but they can also provide information about the state of or events in the mind and mental processes at that moment. For example, a continuous isoelectric EEG (i.e., no EEG activity) signifies that there is no mind or mental processes occurring; a generalized slow-wave EEG that is unresponsive to stimulation signifies that the mind and mental processes are being severely deranged [62,63,189]; continuous 3-Hz spike-and-wave discharges signify that the mind is in the

state of absence seizure [62,64,189–193]; and various sleep EEG patterns signify that the mind is in certain stages of sleep [61,66,194].

As specific patterns of electromagnetic activities are always present when and where there are the mind and mental processes in specific states and change or vanish when and where the mind and mental processes change or cease to exist, the activities of the mind and mental processes are associated with electromagnetic activities. Moreover, because electromagnetic activities in these cases occur from activities of neural processes, not from anything else, it is definite that the activities of the mind and mental processes are associated with the electromagnetic activities of neural processes.

1.2 Theorem I

From the physical properties of PM2.1 to PM 2.8, it can be concluded that, physically, a mental process does not exist and function alone but exists and functions in accordance with and inseparably from a neural process. This theory will state this conclusion concisely as a mental process coexists with a neural process and assert it as Theorem I for a mental process.

Theorem I: A mental process coexists with a neural process.

Similarly, a composite of mental processes coexists with a composite of neural processes. Because the mind is a composite of mental processes, it coexists with a composite of neural processes. Importantly, because the mind can execute all the three activities, including the highest-level ones of the animal (see Section D1.3), the composite of neural processes with which the mind coexists must be able to do the same (to execute all the three activities, including the highest-level ones of the animal). Because the brain is the neural-circuit composite with neural processes that can execute such activities, the mind coexists with the brain. This theory asserts this conclusion as Theorem I for the mind.

Theorem I: The mind coexists with the brain.

Both theorems mean that when and where there is a mental process or the mind—a non-material entity that exists in us (the reader, the author, and other people) and can evidently execute the three activities for us—there is a neural process or the brain that the mental process or the mind coexists with. We will not find a mental process without a neural process; that is, we will not find a mental process in a purely non-neural process part (such as in the blood, extracellular fluid, hair shaft, or nail plate) or outside the body. Similarly, we will not find the mind without the brain; that is, we will not find the mind in other parts of the body, such as in the heart, lungs, or liver, or outside the body. Also, we will not find a mental process or the mind functioning alone, without the same functioning in a neural process or the brain.

It should be noted that the whole functioning nervous system, which is more extensive than the brain because it additionally comprises the spinal cord and peripheral, autonomic, and enteric nervous systems, has neural processes that can execute the three activities, including the highest-level ones of that animal. Thus, it could also be stated that the mind coexists with the whole functioning nervous system instead of the brain. However, as the brain alone can do what the mind is defined to do and as the salient feature of the mind (the ability to process signals at the highest level that that animal can, which can result in consciousness, perception, intelligence, emotion, memory, etc.) exists in the brain even if the rest of the nervous system (the spinal cord and peripheral, autonomic, and enteric nervous systems) is cut off (such as in patients with high cervical cord injury), the brain alone is sufficient for the mind to coexist with. In contrast, this is not true for the isolated spinal cord and peripheral, autonomic, and enteric nervous systems. Although we can say that mental processes coexist with the isolated spinal cord and peripheral, autonomic, and enteric nervous systems, we cannot say that the mind (as defined in Section D1.3) exists in any of them because they lack the salient features of the mind—mental processes in them do not have the ability to process signals at the highest level that the animal can. The mind, with additional mental processes in the spinal cord and peripheral, autonomic, and enteric nervous systems, is thus simply a larger entity than the mind composed of mental processes in the brain alone. It can be considered an extended version of the mind or *the extended mind*, and Theorem I for the extended mind can be stated as “*the extended mind coexists with the whole nervous system.*” The difference between the mind and its extended version is only the number of mental processes that compose them, but they are entities of the same kind—composed of mental processes that coexist with neural processes. Therefore, all conclusions and predictions derived from the principle that mental processes coexist with their neural processes are identical for both the mind and the extended mind.

1.3 Generalizations

All the properties that are used to establish this theorem can be demonstrated in all animals that have a nervous system, including *the most basal animals* (such as Ctenophora [comb jellies], Cnidaria [such as corals, jellyfish, and hydras], the primitive Bilateria [such as small flatworm-like animals in Acoelomorpha]) and *the more advanced animals* (such as more advanced Bilateria, e.g., worms, octopuses, insects, fishes, reptiles, birds, and mammals). Each of these animals has never been found to have the three activities that function for that whole animal without a brain (or brain equivalent). It is to be noted that, although Ctenophora, Cnidaria, and some primitive Bilateria do not have visually recognizable brains but have only nerve nets distributed in their bodies, their whole processing integrated nerve nets are able to perform the three activities at the highest level that these animals can, which can result in complex activities, such as capturing prey, feeding, and fleeing [195–202]. Thus, the whole processing integrated

nerve nets can be considered as functioning brains, or brain equivalents, for these animals. Likewise, although many Protostomes (such as flatworms, roundworms, and mollusks) and some Deuterostomes (such as tunicates, lancelets, and starfish) do not have a definitely-formed brain but instead have a nerve ring connected to a ganglion, a system of several connected ganglia, or a primitive neural vesicle as the center of their nervous systems [197,199–204], these structures are able to perform the three activities at the highest level that these animals can, which can result in complex activities, such as capturing prey, feeding, and fleeing. Therefore, when functioning, these structures satisfy the definition of the brain in this theory and can be considered as brains or brain equivalents for these animals.

Thus, this theorem is generalized to include all animals with a nervous system and, with the mind and mental processes as defined in Section D1.3, the brain as defined in Section D2, and neural processes as defined in Section D5, asserts that a mental process coexists with a neural process and that the mind coexists with the brain for all animals with a nervous system.

1.4 Predictions

1. A mental process (such as the visual-perception, emotion-generation, or thought-formation mental process) will be found to coexist with a certain neural process (such as the visual-perception, emotion-generation, or thought-formation neural process, respectively)—it will not be found to exist and function without a certain neural process. Similarly, a mind will be found to coexist with a brain—it will not be found to exist and function without a brain. This means that, when and where there is a mental process, the neural process that the mental process coexists with will be found then and there; similarly, when and where there is a mind, the brain that the mind coexists with will be found then and there.

In the case of a mental process, it may be difficult to find the neural process that the mental process coexists with because there may be many potential neural processes to consider. However, a neural process can be identified as the neural process of that mental process by investigations that observe and may also manipulate potential neural processes concurrently with observing the mental process. In various investigations, the neural process that consistently changes concomitantly and correspondingly with the mental process will be that neural process. For a certain mental process, this neural process is called the mental process's neural process or its neural process.

2. For a paired mental process and neural process as so identified, every event in the mental process (such as a change of perception from perceiving a flower to perceiving a house, a change of emotion from being happy to being sad, or a

change of determination from resisting to relenting) will be found to be associated with a corresponding, simultaneous event in the neural process (such as an event in a neural process in the occipital cortex, amygdala, or frontal lobe). This association can be investigated by techniques such as fMRI (functional magnetic resonance imaging), MEG, ECoG, and intracortical and single-unit recordings. A mental event will not be found to occur without a corresponding, simultaneous event in the paired neural process. Similarly, for a paired mind and brain as described above, every event in the mind will be found to be associated with a corresponding, simultaneous event in the brain—it will not be found to occur without a corresponding, simultaneous event in the brain.

Up to the present, the predictions of this theorem have been confirmed by everyday clinical events and experimental outcomes. In the previous edition of this theory, it was noted that this theorem could be undermined or even invalidated by the outcome of the AWARE II trial (AWAREness during RESuscitation II trial) [205-207], which followed the AWARE trial [102,106,107], because, according to this theorem, the AWARE II trial would not be able to show that near-death experiences are phenomena that occur in a mind that is anatomically and functionally separated from the brain. Fortunately, shortly before the publication of this book, the AWARE-II study was published [207]. It did not report that cardiac-arrest survival patients had definite episodes of conscious awareness during the periods of no cerebral activity. That is, it did not definitely establish that there were mental processes or the mind functioning in the absence of brain functioning. Therefore, the result of this study does not disprove this theorem. However, as the investigators of the study and its commentators have pointed out, the problems about the phenomenon of Near-Death Experience (NDE) or RED (Recalled Experience of Death) have not been settled by this study, and this phenomenon merits further scientific investigation [207-209], which the author of this theory entirely agrees. Nevertheless, this theorem predicts that no experiments will ever be able to establish that the mind can exist and function separately from the brain.

1.5 Remarks

First, it should be pointed out that many people believe in perfect symmetry between the mind and brain, as does the author. Thus, Theorem I could have been stated to reflect this symmetry as “the mind and the brain coexist with each other.” However, since this theory is scientific and aims to provide verifiable theorems, it cannot assert this statement as a theorem because such a statement is not scientific and not verifiable at present and in the foreseeable future. This is because, given that there is a brain, although we can believe that there is a mind existing with this brain, we cannot scientifically prove that that is the case. At present, other than one's undeniable subjective experience of one's mind, there are no scientific ways for anyone to prove that there truly are non-material

entities of any kinds, including minds, in others. In contrast, Theorem I is scientific and verifiable. If someone asserts that there exists a mind in an animal with a nervous system (human, dog, cat, bird, insect, etc.)—based on whatever evidence—we will scientifically find that there is a brain there. To avoid losing sight of what this means, let us expand the term “mind” according to its definition in Section D1.3. We will find that the above statement means that, if someone asserts that there is a non-material entity that evidently executes the three activities for the whole animal in a human, dog, cat, or any other animal with a nervous system—for whatever reasons—we will scientifically find that there is an alive, processing brain in that animal; we will not find that animal with a dead brain or without a brain. This issue of a scientific theorem needing to be verifiable is also the case for the theorem of the association between a mental process and a neural process. Thus, Theorems I for both mental processes and the mind can be stated only in the forms that appear in Section 1.2.

Next, it should be noted that the concept that the mind and mental processes are closely associated with the brain and neural processes is not a novel one. This concept has long been present in philosophy [1,2,4,210–218], cognitive neuroscience, clinical neurology, and related fields [1,4,8,17,188,219–224]. Currently, scientific evidence (from studies in clinical neurology, neuropharmacology, neuroimaging, cognitive neuroscience, and other related fields) indicating that mental processes are closely associated with their neural processes and that the mind is closely associated with the brain—that the former entities do not exist or function without the latter entities—is overwhelming to the point that this concept is almost irrefutable. Although this fundamental association between the two kinds of entities has not been explicitly stated as a theorem in cognitive neuroscience, neurology, psychiatry, and related fields, it has been the implicit basis of studies, experiments, and treatments related to the mind and mental processes in these fields for a long time, as one can gather from the way studies, experiments, and therapeutic strategies have been designed. To some scientists and philosophers, this theorem may even seem trivial. However, because this concept is the most basic and crucial to understanding the nature of the mind and mental processes, it is proved methodically and explicitly stated as Theorem I of this theory. As will be seen in subsequent chapters, it underpins several other theorems, and certain controversial matters, such as the existence of p-zombies, can be resolved using this theorem alone. This point can be briefly demonstrated as follows: Humans have qualia and consciousness as well as awareness of them (no matter what qualia and consciousness are, we are definitely aware that they occur in us). Thus, we must have a certain neural process functioning for such awareness to occur because, according to this theorem, awareness of anything cannot occur by itself but must occur with some neural process. By their definition, p-zombies do not have qualia and consciousness, so they do not and cannot have awareness of qualia and consciousness. Consequently, they do not have any neural process functioning for awareness of qualia

and consciousness. Hence, humans and p-zombies cannot be physically identical, at least because of the difference in the presence of the neural process for such awareness. However, p-zombies are defined as being physically identical to humans, which is obviously not possible. Therefore, because the definition defines physically impossible entities, p-zombies cannot physically exist. This matter is discussed in more detail in Extra Chapter III.

Finally, it is to be cautioned that, although this theory asserts that mental processes coexist with their neural processes and that the mind coexists with the brain, it does not assert that mental processes are identical with their neural processes and that the mind is identical with the brain. This theory does not support the concept that the mind and the brain are identical. On the contrary, according to this theory, it is basically impossible for mental processes to be identical with neural processes and for the mind to be identical with the brain because, according to this theory's definition, the mind and mental processes are non-material, whereas the brain and neural processes are material. What the mind and mental processes physically and ontologically are will be discussed and identified in the next chapter.

Chapter 2

Theorem II: The Mind is the Composite of All Neural Information-processing Processes

In the previous chapter, it has been shown that a mental process and the mind coexist with, or exist and function in accordance with and inseparably from, a certain neural process and the brain, respectively. However, by what mechanisms do mental processes and the mind do so, and, most importantly, what are they physically and ontologically? This chapter investigates these problems and provides scientific answers to them.

2.1 The Nature of the Mind and Mental Processes

For the mind, there are two mutually exclusive possibilities regarding what it physically is. One possibility is that the mind is a non-material entity that exists and functions separately from the brain, like the soul or spirit (in many beliefs), which is envisioned as a separate entity from the physical body. However, it somehow possesses the body by some mechanism so that it appears to coexist with the brain, which is a must, according to Theorem I. Apparently, this possibility seems improbable because there is a noticeable contradiction: The mind must exist and function separately from the brain but somehow appear to exist and function in accordance with and inseparably from the brain. Nevertheless, let us insist that this possibility is valid and study it to learn comprehensively about the essence of the mind-brain problem and the mind's nature. The other possibility is that the mind is a non-material entity that exists and functions inherently in the brain, with no functionally separate entity occurring, similar to information that exists and functions inherently in electrical currents in a functioning integrated circuit (IC). In the case of a mental process and a neural process, these possibilities are the same. As the mind is composed of mental processes and the brain is composed of neural circuits, of which neural processes are the signal-processing processes, to simplify the investigation, we will investigate this problem in detail by examining the possibility of how a mental process, instead of the much more complex mind, exists and functions with a certain neural process, called its neural process, instead of the much more complex brain.

The two mutually exclusive possibilities for how a mental process exists and functions with its neural process are as follows:

Possibility 1. A mental process is a functionally separate entity from its and all other neural processes—existing and functioning separately from them. Thus, its functions and effects are separate from those of all neural processes. However, it somehow appears to exist and function in accordance with and inseparably from its neural process.

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Possibility 2. A mental process is a functionally inherent entity in its neural process—existing and functioning intrinsically in its neural process. Thus, its functions and effects are inherent in those of its neural process. Naturally, it exists and functions in accordance with and inseparably from its neural process.

The means of identifying which possibility is correct is to examine the physical properties of the entity that a mental process is asserted to be. This means is based on the principle that the entity that a mental process is must have all the physical properties of a mental process. These properties are the physical properties of the mind and mental processes discussed in the previous chapter. They are listed here again for ease of reference:

Physical properties of a mental process (PM)

PM1. Defining physical properties

PM1.1 Its nature is non-material.

PM1.2 Its activities are signal processing.

PM2. Additional physical properties

PM2.1 Its existence is concurrent with its neural process's.

PM2.2 Its location is the same as its neural process's.

PM2.3 Its information is the same as its neural process's.

PM2.4 Its abilities are the same as its neural process's.

PM2.5 Its capacities are the same as its neural process's.

PM2.6 Its chronological aspects are the same as its neural process's.

PM2.7 Its changes are the same as its neural process's.

PM2.8 Its activities are associated with electromagnetic activities.

Next, let us examine the physical properties of the entity in each of the two possibilities as follows:

2.1.1 Possibility 1: A mental process is a functionally separate entity from all neural processes.

Suppose a mental process is an entity M (Figure 2.1) that exists and functions separately from all neural processes and the brain but appears to exist and function in accordance with and inseparably from its neural process, similar to the soul or spirit (in many beliefs), which is envisioned as an entity that is separate from the physical body and brain but seems to possess them.

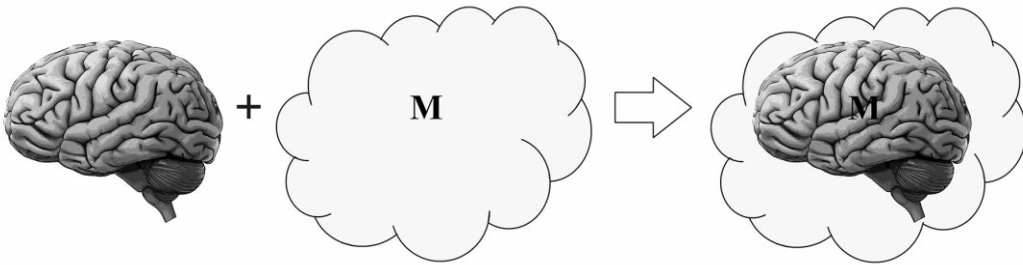


Figure 2.1 M exists and functions separately from all neural processes and the brain.

PM1.1 M's nature is non-material.

This is certainly possible. However, what is the nature of this non-material entity M—what is it made of? At present, there is no answer to this question, and a hypothesis is needed for it.

PM1.2 M's activities are signal processing.

However, if M is a functionally separate entity from all neural processes, which process electrical/electrochemical (E/EC) signals, then the signals that M processes cannot be neural E/EC signals (because we find only one type of E/EC signal in the brain—that of neural processes). The question is what is the nature of the signals used by M in processing?

It is possible that the signals that M uses in its processing are information because information is non-material, as is M. However, if that is the case, then the problem is how M obtains this information. For example, when M (such as the visual perception mental process) deals with the outside world (such as forming mental images of things in the outside world), it must obtain the corresponding information from the outside world. But if M is functionally separated from all neural processes, how can M obtain that information? How can the outside world send the needed information (for images, sounds, smells, etc.), all of which are carried by physical carriers (electromagnetic waves, sound waves, odorant molecules, etc.), to M, and how can the non-material M receive these physical signals (e.g., with what receptors and with what mechanisms)?

It is obvious that these questions are presently unanswerable, and new hypotheses are needed to explain them.

PM2.1 M's existence is concurrent with its neural process's.

However, if M exists and functions separately from its neural process, why is its existence concurrent with its neural process's existence, and what is the mechanism that ties its existence to the existence of its neural process?

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Also, if M exists separately from all neural processes, one crucial question is: What creates it into existence? If there is something that creates M, further questions will arise. For example, what creates that thing; what is the nature of that thing; and how can that thing create M to exist concurrently with its neural process? Alternatively, if M occurs from nothing by itself, many questions will similarly arise. For instance, how can it achieve that; what is the mechanism that connects its existence to that of its neural process so that their existence is concurrent; and what is the mechanism that ties its existence correctly to its neural process's, not wrongly to some other neural process's?

It is obvious that these questions are presently unanswerable, and new hypotheses are needed to explain them.

PM2.2 M's location is the same as its neural process's.

However, if M exists and functions separately from its neural process, how can it always be at the same place as its neural process? That is, how can it follow its neural process simultaneously and correctly, regardless of which way or how fast the head moves (especially when the person runs or travels fast by car, train, or plane)—what is the mechanism that keeps it anatomically fixed with its neural process? Again, a new hypothesis is required to explain this.

PM2.3 M's information is the same as its neural process's.

However, if M is a functionally separate entity from its neural process, its information need not be the same as its neural process's. For example, if M is the visual-perception or auditory-perception mental process, the visual or auditory mental information in the mental process does not need to be the same as the information in the visual-perception or auditory-perception neural process, and the mental images and sounds do not need to be those created by the corresponding neural processes. That is, one can see or hear in the mind what one does not see or hear through the visual or auditory perception neural processes (which function for seeing via the eyes or hearing through the ears and for seeing or hearing in abnormal conditions such as illusions and hallucinations). However, such discrepancies do not occur—what one sees or hears in the mind is always the same as what one sees or hears through the corresponding neural perception processes. Thus, M's information must somehow match its neural process's so perfectly that its information is always the same as its neural process's and thus seems to be its neural process's information, as required. How can M always match its information with its neural process's?

PM2.4 M's abilities are the same as its neural process's.

However, if M is a functionally separate entity from its neural process, its abilities need not be the same as those of its neural process. For example, the human perception mental process may have abilities that the human perception neural process does not

have, such as an ability to sense electricity or magnetism in the form of electroreception or magnetoreception (like those in some animals mentioned in PM2.4-A, the previous chapter). However, such dissimilarities are never the case—the abilities of a mental process are always the same as those of its neural process. Thus, M's abilities must somehow match its neural process's abilities so that its abilities are always the same as its neural process's, as required. How can M achieve that, or what mechanism keeps its abilities always the same as its neural process's?

PM2.5 M's capacities are the same as its neural process's.

However, if M is a functionally separate entity from its neural process, its capacities need not be the same as those of its neural process. For example, the human visual-perception mental process may have capacities that the human visual-perception neural process does not have, such as the capacity to see things in the infrared or ultraviolet range or behind the neck. However, such differences are never true—the capacities of a mental process are always the same as those of its neural process. Thus, M's capacities must somehow match its neural process's capacities so that its capacities are always the same as its neural process's, as required. How can M achieve that, or what mechanism keeps its capacities always the same as its neural process's?

PM2.6 M's chronological aspects are the same as its neural process's.

However, if M is a functionally separate entity from its neural process, its chronological aspects—its starting time, processing rate, and ending time—need not be the same as its neural process's. For example, when our foot hits something hard, the mental process for processing dull, aching pain can start functioning immediately, without waiting for the corresponding neural process to start functioning, and we can feel the pain simultaneously with the hit. When given a problem to solve, the mind can finish it faster or later than its neural process. And when we close our eyes after looking at a bright lamp, the visual perception mental process can stop functioning at once, and we will suddenly see nothing, including no afterimage. But these three scenarios are never true. What really happens has been described in PM2.6, the previous chapter. Thus, M's chronological aspects must somehow match its neural process's chronological aspects so that its chronological aspects are always the same as its neural process's. How can M achieve that, or what is the responsible mechanism?

PM2.7 M's changes are the same as its neural process's.

However, if M is a functionally separate entity from its neural process, its changes do not need to be the same as its neural process's. For example, if M is the visual-perception mental process, its changes do not need to be the same as those of the visual-perception neural process. Consequently, one may still see the same image in the mind even after one has turned to look at other things, or one may see an image in the mind changing continuously even if one still gazes at the same thing. However, this kind of mismatch is

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never the case—a mental process's changes always match its neural process's. Thus, M's changes must somehow match its neural process's so that their changes are the same, as required. How can M achieve that, or what mechanism always keeps its changes the same as its neural process's?

PM2.8 M's activities are associated with electromagnetic activities.

If M's position can somehow be fixed at its neural process, then this property can be fulfilled because M will always be spatially associated with its neural process and thus with its neural process's electromagnetic activities as well. However, as discussed previously in PM2.2, if M is a functionally separate entity from its neural process, how can M always be where its neural process is? Alternatively, if the electromagnetic activities that M's activities are associated with are not those of its neural process, what generates them?

In summary, the possibility that a mental process is a functionally separate entity from its and all other neural processes but can appear to exist and function in accordance with and inseparably from its neural process and have all the required physical properties of mental processes carries several critical questions that are presently unanswerable. Several new hypotheses are needed to support it.

Next, let us examine Possibility 2.

2.1.2 Possibility 2: A mental process is a functionally inherent entity in its neural process.

If a mental process is a functionally inherent entity in its neural process—existing and functioning intrinsically in its neural process—it must be a non-material process that exists and functions inherently in the neural process. What is this non-material process?

When we examine a neural process carefully to find a non-material process that exists and functions inherently in it, we will find the following: When a neural process, which is the signal-processing process of a neural circuit, is functioning, material E/EC signals will be circulated and processed in the circuit. However, these are not the only things that are circulated and processed in the circuit. Information—a non-material thing that is transferable and consists of content⁵—is always circulated and processed simultaneously. This is because information is an inherent, non-material counterpart of material E/EC signals. Therefore, in the entirety, two processing processes occur concurrently in a neural process. The first is an obvious material process: ***the electrical/electrochemical-signal-processing process (EPP)***. The other is an inconspicuous, non-material process: ***the information-processing process (IPP)***. Both processes not only occur simultaneously

⁵ For a more detailed discussion of this point, please see *Introduction and Definitions: Section D8 and Extra Chapter I: Information*.

but also are inseparable—they cannot occur independently of each other. Each is an inherent counterpart of the other: The EPP is the inherent material counterpart of the IPP, and the IPP is the inherent non-material (informational) counterpart of the EPP. Both constitute the neural process in different but complementary aspects: The EPP, the material aspect, and the IPP, the informational aspect.

Because the IPP is a non-material process that exists and functions inherently in its neural process, it qualifies as the entity that a mental process is. If we verify this concept with all mental processes, which are the entities that perform sensation and perception, integrative and control, and response or output functions, we will find that all mental process functions are indeed related to information processing. Therefore, it is probable that every mental process is an IPP (depicted as looping arrows existing in the brain in Figure 2.2 below).



Figure 2.2 A functionally inherent IPP (looping arrows)

We must now verify whether this hypothesis is correct. If a mental process is an IPP, then the IPP must have all the physical properties of a mental process; otherwise, the mental process cannot be the IPP. Does an IPP have all the required properties? This can be verified as follows:

PM1.1 An IPP's nature must be non-material. This property is satisfied because the IPP is non-material, as discussed above. Moreover, because the specific nature of an IPP is already known—it is a non-material, information-processing process—no additional hypotheses are needed to describe its physical or ontological nature.

PM1.2 An IPP's activities must be signal processing. This property is satisfied because IPPs process information, which is a non-material signal that is the counterpart of material E/EC signals.

PM2.1 An IPP's existence must be concurrent with its neural process's. This property is satisfied because the IPP is an informational aspect of its neural process; its existence is naturally concurrent with that of its neural process. This is why a mental

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process, if it is an IPP, always exists concurrently with its neural process and never exists alone or with anything else.

PM2.2 An IPP's location must be the same as its neural process's. This property is satisfied because the IPP is an informational aspect of its neural process; it is always in its neural process. This is why a mental process, if it is an IPP, is always where its neural process is, regardless of which way or how fast the head moves.

PM2.3 An IPP's information must be the same as its neural process's. This property is satisfied because an IPP is the informational aspect of its neural process; its information naturally is its neural process's information. This is why a mental process and its neural process always have the same information.

PM2.4 An IPP's abilities must be the same as its neural process's. This property is satisfied because an IPP is an inherent aspect of its neural process; consequently, its abilities must be the same as those of its neural process. This is why a mental process, if it is an IPP, can do only what its neural process can and cannot do what its neural process cannot.

PM2.5 An IPP's capacities must be the same as its neural process's. This property is satisfied because an IPP is an inherent aspect of its neural process; accordingly, its capacities must be the same as those of its neural process. This is why a mental process, if it is an IPP, can perform activities only within the limited capacities of its neural process and cannot perform activities exceeding the capacities of its neural process.

PM2.6 An IPP's chronological aspects are the same as its neural process's. This property is satisfied because an IPP is the information-processing process—the counterpart of the E/EC signal processing process of its neural process—its chronological aspects must be the same as its neural process's. This is why a mental process, if it is an IPP, has the same starting time, processing rate, and ending time as its neural process.

PM2.7 An IPP's changes must be the same as its neural process's. This property is satisfied because an IPP is an inherent aspect of its neural process; its changes are naturally the same as its neural process's. This is why a mental process, if it is an IPP, must change when its neural process changes, cannot change if its neural process does not, and must change concurrently with and according to its neural process's changes.

PM2.8 An IPP's activities must be associated with electromagnetic activities. This property is satisfied because an IPP is always where its neural process is, as discussed in PM2.2, and because a neural process is always associated with electromagnetic activities. This is why a mental process's activities, if the mental process is an IPP, are always associated with electromagnetic activities and cannot exist without associated electromagnetic activities.

Evidently, an IPP possesses all the listed physical properties of mental processes. Moreover, because an IPP is non-material, it also has other physical properties that we commonly recognize, such as being shapeless, soundless, tasteless, odorless, and intangible. That is why we cannot see, hear, taste, smell, or touch an IPP, even though we have dissected countless brains and scrutinized them using various methods, from our eyes to the most advanced electron microscopes.

However, having all the required physical properties may not be sufficient for an IPP to be the entity that a mental process is. We must examine whether the IPP has the functional properties of a mental process, that is, whether it can function as a mental process can, which can be assessed as follows: First, what a mental process can do or be depends on its abilities, capacities, and information. Second, the abilities, capacities, and information of a mental process are the same as or do not exceed those of its neural process (see the previous chapter). Third, the abilities, capacities, and information of the IPP are the same as those of its neural process (as discussed above). Therefore, the abilities, capacities, and information of a mental process are the same as or do not exceed those of the IPP. Thus, whatever a mental process can do or be, the IPP can do or be. Hence, regarding the functional properties that some philosophers believe are the properties of the mind and mental processes, such as being private, subjective, intentional, and representational, and having propositional content [1–10], an IPP also has these properties. For example, because an IPP occurs privately in an individual, as its neural process does, and because only that individual is the subject who possesses the neural process and experiences the IPP, an IPP is necessarily private and subjective, like a mental process. Similarly, if a mental process of a certain neural process represents something, then the IPP of that neural process represents that thing as well because the IPP has the same information as the neural process, which is the same as or not less than the information of the mental process. In general, if it can be asserted that a mental process of a certain neural process has some properties, such as being intentional, according to some arguments, then an IPP, which has no fewer abilities and capacities and no less information than the mental process, can also be asserted to have those properties through the same arguments. Therefore, in all aspects, both physical and functional, IPPs have the same properties as mental processes.

2.2 Theorem II

In summary, there are two possibilities: 1) a mental process is a functionally separate entity from all neural processes, and 2) a mental process is a functionally inherent entity in its neural process—specifically, an IPP. The first possibility requires an unknown entity and several additional hypotheses to explain how the entity can have the “must-have” physical properties of a mental process. In contrast, the second possibility does not have to invent a new entity—IPPs are already existing entities in neural processes—and they possess all the required physical properties of mental processes without having to

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formulate additional hypotheses to explain how they can do so. Therefore, based on parsimony, it is rational to choose the second possibility and conclude that a mental process is an IPP. This theory asserts this conclusion as Theorem II.

Theorem II: A mental process is the information-processing process of its neural process.

Thus, all mental processes are the information-processing processes of all neural processes. Because the mind is a composite of all mental processes, it is a composite of all neural information-processing processes. Theorem II regarding the mind can thus be stated as follows:

Theorem II: The mind is the composite of all neural information-processing processes.

The above statement is the general form of Theorem II. However, to differentiate between the mind and the extended mind (a type of mind discussed in Section 1.2), we can be more specific by stating that *the mind is the composite of all neural information-processing processes existing with the brain* and that *the extended mind is the composite of all neural information-processing processes existing with the whole nervous system*.

Now, because the mind is a composite of information-processing processes, it is an *informational entity*—a non-material entity composed of information and information processing—and because the information-processing processes that form the human mind are innumerable and involve information that ranges from simple to advanced, such as complex sensory perception, problem-solving operation, and motor command execution, the human mind is an informational entity in a highly advanced form.

In conclusion, the mind—a non-material entity that exists in us (the reader, the author, other people, and our relatives: other animals with a nervous system) and can evidently execute the three activities (sensing, processing, and sending signals) for each of us—is the composite of all neural information-processing processes. A novel entity is not needed to account for the mind.

Hence, if we could somehow shrink ourselves to the size of viruses and journey through the brain, we would neither be able to spot mental processes nor the mind if we looked only at material components (neural circuits, supporting tissue, circulating blood, etc.). Similarly, walking through Leibniz's mill [11–14], one would find only mechanical parts pushing and pulling each other but could not find something that could be sensation, perception, or thought if one looked only at mechanical parts. Yet, to account for mental processes and the mind, we do not have to conceive novel, non-material entities. The mind and mental processes are already there—being the inherent neural information-

processing processes of the brain and subtly existing in its neural processes. Likewise, in the case of Leibniz's mill, one does not have to invent novel, non-material entities, such as monads, to be perception, sensation, and thought in the mill. These entities are already there—being the inherent information-processing processes of the mill and invisibly existing in the pushing-pulling processes of the mechanical parts of the mill.

Finally, because mental processes and the mind inherently co-function with material processes—the EPPs, which can physically affect the outside material world—mental processes and the mind can affect the outside material world. However, they do not and cannot do this separately from the EPPs, and the EPPs do not and cannot do this separately from mental processes and the mind. Both types jointly affect the external material world as a single entity. This answers the question of how mental processes and the mind, which are non-material, can affect material entities in the physical world.

2.3 Implications and Predictions

Implications

Because the EPP, or E/EC signal-processing process, of a certain neural process is the material counterpart of the IPP, or mental process, of the same neural process, the physical characteristics of the EPP can be surrogates for those of the mental process (IPP). Therefore, it is possible to study (measure, monitor, compare, etc.) a mental process physically (qualitatively and quantitatively) by studying the physical characteristics of its neural process's EPP, such as the number of neurons participating in the processing, details of the signaling, and electrical and magnetic parameters of the processing. For example,

- EPP characteristics, such as the signaling pattern, can be used to identify the exact mental process that is occurring, such as the exact visual image, thought, or emotion that is occurring in a person's mind at the time of examination. This could be the basis for mind reading.

- EPP characteristics, such as the number of neurons participating in the processing process or the electrical or magnetic parameters of the processing process, can be used to objectively quantify and compare mental processes, such as to quantify the intensity of the feeling of pain, anger, or alertness that a person is experiencing, and to compare who is stronger experiencing pain or anger or who is more alert. This could be the basis for various types of mental meters.

In addition, because EPPs and IPPs are inseparable counterparts and can neither occur nor function independently of each other, anything that affects the EPPs will simultaneously and similarly affect the IPPs. Therefore, they are always created, changed, and destroyed simultaneously and similarly in all events and experiments. This can be the basis for experiments using EPPs as surrogates to study IPPs and mental processes.

Predictions

1. A mental process can be identified, quantified, or monitored by identifying, quantifying, or monitoring, respectively, only its EPP. These EPP investigations are both necessary and sufficient for the corresponding mental process investigations to result, while these actions on anything else without involving the EPP will not result in the corresponding mental process investigations.

Note. An EPP can be identified as the EPP of a mental process by investigations that observe and may also manipulate potential EPPs concurrently with observing the mental process. In various investigations, the EPP that consistently changes concomitantly and correspondingly with the mental process will be that EPP.

2. A mental process can be created, modified, tested, or destroyed by creating, modifying, testing, or destroying, respectively, only its EPP. These actions on the EPP are both necessary and sufficient for the corresponding actions on the mental process to occur, while these actions on anything else without involving the EPP will not result in the corresponding actions on the mental process.
3. In an event or experiment, all predictions that are valid for an EPP, such as whether the EPP will occur, change, or disappear, will be identically valid for the mental process of that EPP; that is, the changes that occur in the EPP and those in the mental process of that EPP will be identical in all aspects (quality, quantity, temporal pattern, etc.). For example, if it is predicted that the EPP will change its function abruptly from processing visual signals of a static, faint, homogeneous red color to processing visual signals of a dynamic, vivid, complex movie, it will be found that the changes in the mental process of that EPP will be identical in all aspects, such as identical changes from a homogeneous color to a complex movie (quality), from faint to vivid (quantity), and abruptly from static to dynamic (temporal pattern).

All the above predictions can be verified by experiments in conscious, communicative human subjects. A typical experiment is to monitor a mental process's occurrence, existence, change, etc. by having the subject report what happens to his or her mental process while concomitantly monitoring the EPP by methods such as fMRI [15–23], MEG [18,24–28], ECoG [29–44], stereoelectroencephalography [45,46], and single-unit recordings [47–54] and while the subject's EPP is being manipulated by methods such as drug administration, electrical stimulation [55–63], or magnetic stimulation [64–77].

2.4 Remarks

Preceding concepts

It should be noted that the idea that mental processes are, are represented by, or are caused by specific brain processes is not novel. For example, Smart (1959) said that

“When I say that a sensation is a brain process ..., I am using is in the sense of strict identity.” [78]; **Bogen (2007)** said that *“... every sensation, thought, feeling, memory, and expectation is represented in the brain by a neuronal activity pattern (NAP).”* [79]; **Dehaene (2014)** said that *“Many stimulation studies ... have demonstrated a direct causal mapping between neural states and conscious perception. ... that the relation between these neuron’s firing and the corresponding perception is causal ... that your mental life arises entirely from the activity of the brain.”* [80]; **Moutoussis (2016)** said that *“... a specific brain-activation pattern, leading to the formation of a specific percept. ... specific, individual perceptual experiences are caused by specific, individual brain activation pattern ...”* [4]; **Roederer (2016)** said that *“when does a specific distribution of neural firings actually become a mental image? This neural activity distribution does not become anything—it is the image”* and that *“the dynamic spatio-temporal distribution of neural impulses and the quasi-static spatial distribution of synapses and their efficiencies together are the physical realization of the global state of a functioning brain at any instant of time.”* [81]; lastly, **Weisberg (2018)** said that *“First, we find stimuli that reliably trigger reports of phenomenally conscious states from subjects. Then we find what neural processes are reliably correlated with those reported experiences. It can then be argued on the basis of parsimony that the reported conscious state just is the neural state.”* [10].

The concept that the mind and mental processes are signal-processing processes, information-processing processes, computational devices, or computing systems is not novel either. For example, **Varvatsoulas (2014)** discussed in detail various opinions on the concept that the human mind is a computational process device [82]; **Velmans (2002,2009)** said that *“we can say that mind is a psychophysical process that encodes information, developing over time.”* [83] and that *“mind can be thought of as a form of information processing,”* [84]; **Rescorla (2020)** discussed the Computational Theory of the Mind, which many philosophers supported and which states that the mind is a computing system [85]; lastly, **Doyle (The Information Philosopher)** said that *“The mind is a biological information processing system.”* [86] and that *“The mind is the immaterial information in the brain.”* [87] These ideas are also evident in science fiction. The movie series The Matrix, for example, certainly based their plots on these principles. Also, **Doyle (The Information Philosopher)** proposed, before this theory, that information, which is neither matter nor energy, might provide the basis for a kind of mental substance and said that *“immaterial information is as close as a physical or biological scientist can get to the idea of a soul or spirit.”* [88] These concepts are very similar to the concept of this theorem, which is that neural information-processing processes have the right properties—being non-material and having all other required physical properties—to be mental processes and the mind. However, this theory proves these concepts methodically and states them explicitly as a theorem, which, to the author’s knowledge, has never been done before.

Physicalism and dualism

Since the mind is the composite of all neural information-processing processes, if we consider information-processing processes to be physical entities (because information-processing processes are governed and predictable by physical laws), then the mind is a physical entity. In this sense, this theory accords with physicalism [89–91], which holds that everything is physical—governed and predictable by physical laws. However, because the mind is an information-processing entity, it is an **informational entity**—a non-material entity that is composed of information and information processing—and not a **conventional physical entity**, such as mass, energy, or force, which is composed of elementary particles and their interactions and is called **mechanical entities** in this theory.⁶ Thus, the mind is basically different from mechanical entities. This is also true for mental processes. Therefore, there are two basically different classes of entities in the universe: **the mechanical class** and **the informational class**. The former consists of **mechanical entities**—all things that are composed of elementary particles and their interactions, such as mass, energy, force, and other complex mechanical entities, such as the brain, neural circuits, and electronic circuits; the latter consists of **informational entities**—all things that are composed of information and information processing,⁷ such as the mind, mental processes, and information-processing processes in electronic circuits. However, these two classes of entities are not separate; they are inherently and inseparably connected and function in a unified manner. They are counterparts and are simply two different sides of some single entity. That is, the brain and mind are counterparts of each other and are the mechanical and informational sides, respectively, of the same brain-mind entity. Similarly, the EPP and the IPP are counterparts of each other and are the mechanical and informational sides, respectively, of the same neural process. It is the nature of this universe that there exist not one but two sides to everything. Thus, this theory concurs with dualism [9,10,92–94] in the sense that there are two basically different classes of entities in this universe. However, because they function in a unified manner, this theory does not agree with dualism in the sense that there are two classes of entities that function independently of each other in this universe.

Again, it is to be noted that the concept that the mind and brain are complementary parts or counterparts is not new. Similar concepts have been previously proposed. For example, **De Sousa (2013)** said that “*The Mind is the functional correlate of the brain, while the Brain is the structural correlate of the mind. One is an entity and the other is its*

⁶ This “mechanical” term is similar to that used by Velmans (2009): “The stuff of the world is purely mechanical, following mathematically describable laws.” [84].

⁷ To avoid losing sight of what information in this theory means, please recall that it refers to a non-material thing that is transferable, consists of content, and has effects on the receiver and that, ontologically, it is the pattern of its physical carrier or counterpart. For more details on this matter, please see Extra Chapter I: Information.

operational correlate...” [1]; **Singh (2011)** said that “*The brain-mind dyad must be understood, with brain as the structural correlate of the mind, and mind as the functional correlate of the brain.*” [95]; lastly, **Panksepp (2011)** said that “*Hence it may be wiser to have a monistic term, that does not prioritize either mind or brain, but combines the concepts into a unified term (common variants are brain-mind or mind-brain).*” [96]. The idea of a dual manifestation of things, similar to the dual manifestation of the neural process as the EPP and IPP, is not novel either. This idea has been presented previously. For example, **Solms and Friston (2018)** [97] said that “*seeing oneself (exteroceptive perspective) and being oneself (interoceptive perspective) realise two aspects of the same thing: the ‘physical’ body (as seen) and ‘mental’ being (as felt) are dual aspects of a single entity. Experience accordingly does not ‘arise from a physical basis’; rather, the physical (what is seen – exteroception) and the mental (what is felt – interoception) are dual manifestations of unitary underlying processes. What is seen does not cause what is felt. Both have hidden causes.*” Some important variants of the dual-aspect thinking of the 20th century have been instructively discussed and compared by **Atmanspacher (2014)** [98]. However, the ontological nature of the complementary part or counterpart of the brain—that is, the mind—has never been identified before. This theory complements the existing concept by determining that the counterpart of the brain is the composite of all neural information-processing processes existing with the brain.

Looking ahead

The puzzles regarding the mind and mental processes have not yet been completely solved. Theorems I and II are valid for the mind and all mental processes. However, when the mind and mental processes function, mental phenomena called qualia and consciousness sometimes occur. What are these additional phenomena? Why and how do they occur? These questions will be addressed in the following chapters.

*What happens when we see, hear, smell,
and feel things around us,
experience moods, think of various things, plan actions,
and command our hands, lips, and body to move,
if not information, information, and information
are processed?*

*We are just informational entities,
composed of information and information processing ...
existing on the informational side of the universe.*

Chapter 3

Qualia, Conscious Awareness, and Conscious Experience

Qualia are mental phenomena that have been fascinating and bewildering human minds for a long time. They are the phenomena that make us live not in the dark but in the dazzling world of images, sounds, scents, etc., yet their nature is mysterious. Many questions about them, in particular, the question of what they are physically and ontologically and the questions of why and how they occur—which are widely known as “the hard problem of qualia” or the closely related “the hard problem of consciousness” [1–19] and “the explanatory gap” [4,5,6,7,12,13,16,18–29]—are still unresolved. Because of the difficulties in answering these questions, three chapters are dedicated to analyzing them. The first one, this chapter, clarifies what qualia are manifestation-wise, explains their definitions and types, and includes discussions about their closely associated phenomena—conscious awareness and conscious experiences. The second chapter answers the question of whether they are physical phenomena or not. Lastly, the third chapter solves the problems of what they are physically and ontologically, why and how they occur, and other related questions.

3.1 Quale and Qualia: Definition

When one looks at a house, the image of the house appears in one’s mind, and one can be aware of it and experience it in one’s mind (Figure 3.1). When one listens to a song, the sound of the song appears in one’s mind, and one can be aware of it and experience it in one’s mind. When one smells a flower, the odor of the flower appears in one’s mind, and one can be aware of it and experience it in one’s mind.



Figure 3.1 Image, sound, and odor qualia

In addition, similar phenomena related to other kinds of sensory perception (taste, touch, pain, etc.) can appear in one's mind, and one can also be aware of them and experience them in one's mind. Moreover, other mental phenomena that are not sensory perception, such as emotions, thoughts, and recalled memories, can appear in one's mind, and one can be aware of them and experience them in one's mind as well.

If we examine how the mind is aware of and experiences these phenomena, we will find one essential characteristic: For each phenomenon, in addition to being aware of its occurrence, *the mind is aware of and experiences what the phenomenon is like*—what the image of a house is like, what the sound of a song is like, what the odor of a flower is like, etc. In other words, the mind has awareness and an experience of what the phenomenon is like, and *awareness and an experience of what the phenomenon is like occur in the mind*. In this theory, when a) the mind is aware of and experiences what a mental phenomenon is like or, equivalently, b) awareness and an experience of what the phenomenon is like occur in the mind, the mind is said to *be consciously aware of and consciously experience* that mental phenomenon. Vice versa, a mental phenomenon is said to be consciously experienceable if a) or, equivalently, b) can be the case.

Definition: A mental phenomenon is consciously experienceable if the mind can be aware of and experience what that phenomenon is like.

Or, equivalently:

Definition: A mental phenomenon is consciously experienceable if awareness and an experience of what that phenomenon is like can occur in the mind.

The crucial point regarding the definitions is: How do we know that the mind can be aware of and experience what that phenomenon is like and that awareness and an experience of what that phenomenon is like can occur in the mind? The answer is that there must be behavioral evidence for them. Normally, when a) or b) is the case, the mind can tell that the phenomenon has happened, can hold it in the working memory, and can distribute its information globally to other parts of the mind, including the cognition, symbolization, and memorization parts.⁸ This global information sharing results in various additional mental activities. For example, the mind can think about, analyze, compare, and intentionally perform other cognitive activities regarding this phenomenon; can represent it with a symbol or sign (such as a written sign, sound, or gesture), thereby being able to report it to the outside world; and can intentionally remember it and recall it

⁸ This is the current concept about this phenomenon. It is held by many scientists and philosophers (for example, see References 30–37) and current leading consciousness theories such as *The Global Workspace theory* [38–42], *The Global Neuronal Workspace hypothesis* [43–49], and an *extended theory of global workspace of consciousness* [50].

later. These activities are behaviorally evident and verifiable in normal people. Therefore, we can determine whether condition a) or, equivalently, b) is satisfied by checking whether the person whose mind is being investigated has these activities.

However, these assessments may not be possible in people with concentration, language, memory, motor, or other problems that impair the mind's ability to report what has happened in it. In such cases, we cannot tell whether the phenomenon in question is experienceable because a) and b) are not verifiable. Thus, this theory will not include such cases in the study. More advanced theories are needed to cover them. Nevertheless, we will see that such irregular cases do not prevent us from discovering what a consciously experienceable mental phenomenon is because the regular cases give us enough evidence to do so.

Next is a seminal point. Not all mental phenomena are consciously experienceable. Those that are not have quite different characteristics. The mind is aware of them in other ways. It is aware of them in the sense that it registers their occurrences and information into its processing systems and subsequently reacts to them, but it *is not aware of and does not experience what they are like*. Examples of such mental phenomena are those occurring in the perception and control of the blood constituent levels (e.g., sodium, oxygen, and sugar levels), of the pressure in the vessels (arterial, venous, and lymphatic), and of the reflexes (myotatic, gastrointestinal, autonomic, etc.); please see Figure 3.2B.

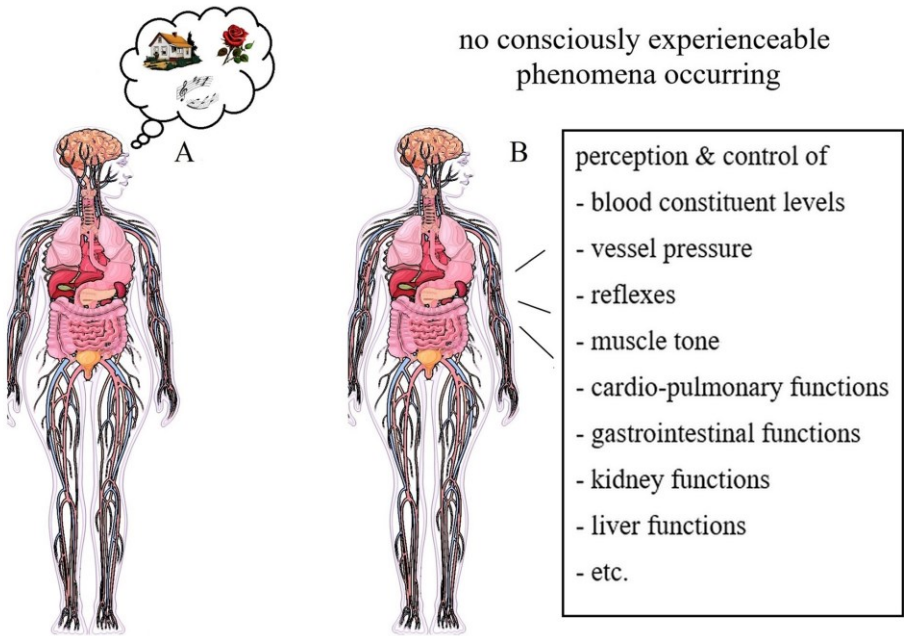


Figure 3.2 Mental phenomena that (A) are and (B) are not consciously experienceable

Again, the mind is aware of these mental phenomena in some ways—it registers them and their information and reacts to them accordingly all the time but is not aware of and does not experience what they are like. For example, it is not aware of and does not experience what the perception and control of the blood constituent levels, of the pressure in the vessels, and of the reflexes are like. Additionally, the mind cannot tell that these phenomena have happened, cannot hold them in the working memory, and cannot send their information to some important parts of the mind, such as the cognition, symbolization, and memorization parts. Hence, it cannot think about, analyze, compare, or intentionally perform other cognitive activities regarding these phenomena, cannot represent them with symbols or signs, thus unable to report them to the outside world, and cannot intentionally memorize them.

Therefore, some mental phenomena are consciously experienceable (Figure 3.2A), while others are not (Figure 3.2B). In this theory, mental phenomena that are consciously experienceable are called *qualia* (plural and adjective form) or *quale* (singular form).

Definition: A mental phenomenon that is consciously experienceable is a quale.

And, in this theory, the term quale is used to represent only this mental phenomenon.

Definition: A quale is a mental phenomenon that is consciously experienceable.

Accordingly, the mental phenomena previously used as examples above, such as the image, sound, odor, emotion, and thought, are qualia because they are consciously experienceable (the mind can be aware of and experience what they are like). In contrast, mental phenomena such as those that occur in the perception and control of the blood constituent levels, of the pressure in the vessels, and of the reflexes are not qualia because they are not consciously experienceable (the mind cannot be aware of or experience what they are like).

Note. Since short terms such as image, sound, and odor, when used in this context—discussing phenomena happening in the mind—refer to image quale, sound quale, and odor quale, respectively, they are used in this manner throughout this theory to maintain conciseness. However, explicit, longer terms such as image quale, sound quale, and odor quale will be used when it is pertinent to emphasize that they are qualia. Also, it is worth noting that these short terms can mean something else when used in other contexts, such as an image appearing on a TV screen, sound emitting from a speaker, and odor wafting from a scent bottle, which refer to physical phenomena happening outside the mind, not qualia.

Interestingly, some phenomena can alternate between being and not being consciously experienceable, such as those that occur in binocular rivalry [51–58]. In such a case, only the phenomenon in a consciously experienceable state will be a quale in this theory; the same phenomenon, when it is in a state that is not consciously experienceable, will not be a quale in this theory because, while being in that state, it does not satisfy the definition of a quale.

Lastly, regarding their etymology, the terms quale and qualia are derived from the Latin word “quālis” [59–61]—meaning “what sort” or “what kind” [29,59–63]. Although these two terms were first used in philosophy in 1929 by Lewis CI in a discussion of sense-data theory [28,29,64,65], at present, they are used by philosophers, cognitive neuroscientists, and scientists in related fields to refer to the phenomena as defined above or other closely related phenomena [40,62,66–78]. However, since the standard definitions of the two terms have not been settled, some authors use other definitions, and their “quale” and “qualia” may not be “quale” and “qualia” as defined here. Moreover, some use other terms such as consciousness, experience, and phenomenal experience to refer to these phenomena [8,79]. Therefore, the reader should be careful about their meanings when encountering these terms in the literature. Accordingly, to avoid confusion, the working definitions of the two terms in this theory will specifically be as stated above.

3.2 Phenomenal Characteristic and Phenomenality

Because qualia are consciously experienceable, the mind can be aware of and experience what they are like (what an image of a house, a sound of a song, an odor of a flower, etc. are like), and awareness and experiences of what they are like occur. This means that qualia must manifest what themselves are like in the mind so that such awareness and experiences can occur [1,2,4,5,13,14,29]. Thus, qualia can also be defined as “*mental phenomena that manifest what themselves are like in the mind.*” This characteristic of qualia—*manifesting what themselves are like in the mind*—is called *phenomenal characteristic* [29,78] or, in short, *phenomenality*.⁹ It is a key characteristic and the heart of the hard problem of qualia: why and how qualia manifest what themselves are like in the mind. When this characteristic is to be emphasized, the terms *phenomenal quale/qualia* will be used instead of quale/qualia. Similarly, a manifestation of what the quale (of something) is like in the mind will be called a *phenomenal manifestation*, and qualia can be defined as “*mental phenomena that exhibit phenomenal manifestations*” as well.

Other important characteristics of a quale that are inherent in its phenomenality or its manifesting what itself is like in the mind are that each quale is

⁹ Other similar terms are *phenomenal character* [4,13,29,65,80–82] or *phenomenal properties* [4,5,13,16,19,65,80,83].

a) **unique in its manifestation**—the manifestation of each quale is different from those of other qualia and other phenomena and

b) **ineffable**¹⁰ or **indescribable**—a quale cannot be described based on anything else and must be experienced by a person for that person to know “what the quale is like.”

For example, an image quale of a house and a sound quale of a song are unique in their manifestations (both are unique and drastically different from each other and from other qualia, such as odor qualia, thought qualia, and emotion qualia) and are ineffable (one cannot describe to a congenitally blind person what an image quale of a house is like based on what sound, odor, touch, and other qualia are like, nor can one describe to a congenitally deaf person what a sound quale of a song is like based on what image, odor, touch, and other qualia are like—they must be experienced by a person for that person to understand “what an image quale of a house” is like and “what a sound quale of a song” is like).

3.3 Types of Qualia

Many mental phenomena are qualia [87]. Let us examine this matter in detail because it will provide clues to qualia’s nature.

Based on what kind of information they are, qualia can be classified into two types:

1. Sensory perception qualia
 - External-sensory perception qualia
 - Internal-sensory perception qualia
2. Emotion-cognition-execution qualia

1. Sensory perception qualia are qualia that occur as the products of sensory perception. They can be subdivided into external- and internal-sensory perception qualia. External-sensory perception qualia are qualia that occur as the products of external-sensory perception, which perceive stimuli occurring outside the body. In humans, there are several kinds of them: visual, auditory, olfactory, gustatory, and somatosensory perception qualia.¹¹ Internal-sensory perception qualia are qualia that occur as the products of internal-sensory perception, which perceive stimuli occurring inside the body. In humans, several kinds of them exist: vestibular, proprioceptive, and visceral sensory (i.e., visceral pain, distension, cramp, etc.) perception qualia. It is possible that some animals that have sensory perception humans do not have (such as magnetoreception in

¹⁰ This word comes from the Latin word “*ineffabilis*,” which means “cannot be described” or “unutterable.” [84–86].

¹¹ In this theory, visual, auditory, and olfactory qualia are the same as image, sound, and odor qualia, respectively. The former terms will be used most of the time, while the latter terms will be used sometimes when simplicity is appropriate. Also, the term “mental image” will be used instead of “image” when it is to be emphasized that it is an image in the mind.

birds, bats, bees, and sharks [88–90], electroreception in electric fish [91–96], and hygroreception in insects [97–100]) have other kinds of qualia for these kinds of sensory perception as well [101]. Each kind of sensory perception quale has a unique manifestation, cannot be described based on any other qualia or anything else, and must be experienced to understand what it is like (e.g., what a visual quale is like, what an auditory quale is like, or what a proprioceptive quale is like). Furthermore, each kind of sensory perception quale consists of several components that are basic qualia. For example, visual qualia consist of several basic qualia—color, brightness, shape, and other basic visual qualia; while auditory qualia consist of several other basic qualia—pitch, timbre, loudness, and other basic auditory qualia. Each component or basic quale has a unique manifestation, cannot be described based on any other basic qualia or anything else, and must be consciously experienced to understand what it is like (e.g., for visual qualia: what a color quale is like, what a brightness quale is like, or what a shape quale is like). Sensory perception qualia, both external and internal, are information about something in the outside world (which can be either outside or inside one's body). They are usually vivid in their manifestations.

It is essential to note that not all perception of stimuli occurring inside the body has products or other components that are consciously experienceable or are qualia. In fact, perception of most internal stimuli, which convey information from various organs, tissues, or cells inside the body, such as perception of the blood constituent levels (e.g., sodium, oxygen, and sugar levels), of the pressure in the vessels (arterial, venous, and lymphatic), and of various reflexes (myotatic, gastro-intestinal, autonomic, etc.), does not have qualia in their processes. We never know what their products or other components are like (such as what the products or other components of the perception of various blood constituent levels, pressure in our vessels, and various reflexes are like). Similarly, it is crucial to note that sensory perception qualia do not occur in all sensory-perception processing processes but only in the final-stage processing processes, such as the final-stage visual-perception processing processes (which create visual qualia of color, brightness, shape, etc.) and the final-stage auditory-perception processing processes (which create auditory qualia of pitch, timbre, loudness, etc.). All the earlier stages of sensory perception, such as the first stage of processing raw sensory signals arriving at each primary sensory perception area, do not have products or other components that are consciously experienceable or are qualia. We never know what the products or other components of such earlier-stage perception are like. The fact that some perception has qualia, whereas some does not, and the fact that qualia occur only in the final-stage sensory-perception processing processes can provide clues to why and how qualia and consciousness occur. This point will be discussed in more detail in the following chapters.

2. Emotion-cognition-execution qualia are qualia that occur as the products of the processes that process emotion, cognition, and execution. They occur as the products of

emotion-generation processes (such as a happy, sad, or angry feeling), cognitive perception processes (such as perception of time, existence, or self and non-self), and cognition-execution processes (such as a thought of one's self, a recalled past event, or a mental plan). Similar to sensory perception qualia, each kind of these qualia has a unique manifestation, cannot be described based on any other qualia or anything else, and must be consciously experienced to understand what it is like (e.g., what the emotion quale of happiness is like, what the perception quale of time is like, or what the thought quale of one's self is like). Emotion-cognition-execution qualia are information about emotion, cognition, or execution, all of which are inside the mind, not in the external world. They are usually not as vivid in their manifestations as sensory perception qualia.

Similar to the case of sensory perception qualia, it is imperative to notice the selectivity of qualia occurrences in this case. All emotion-cognition-execution qualia occur exclusively in the final-stage processing processes of these highest-level mental processes. All earlier stages of these mental processes and all lower-level mental processes, which constitute the vast majority of mental processes, such as the mental processes of the basal ganglia, brainstem nuclei, and cerebellum, do not have products or anything that are consciously experienceable or are qualia. We never know what these mental processes' activities, products, and other components are like, such as what the early-stage processing of emotion, cognition, and execution are like and what the processing of the extrapyramidal motor control, cerebellar motor control, and autonomic control of body temperature, heart rate, and various blood constituent levels are like. Again, the fact that some mental processes have qualia, whereas others do not, and the fact that qualia occur only in the final-stage processing processes of some highest-level mental processes can provide clues to why and how qualia and consciousness occur. This point will be discussed in more detail in the following chapters.

3.4 Conscious Awareness and Conscious Experience

As discussed in Section 3.1, when the mind is aware of and experiences a quale, not only *awareness and an experience of the quale's existence* but also ***awareness and an experience of what the quale is like occur***. On the other hand, when the mind is aware of and experiences something that is not a quale, some kind of awareness and experience of that thing's existence occurs, and the mind responds to them accordingly, but ***awareness and an experience of what that thing is like do not occur***. Therefore, awareness and an experience of what a quale is like (such as awareness and an experience of what an image of a house, a sound of a song, or an odor of a flower is like) are special because they are additional awareness and experience and occur only when we are conscious in the usual sense. (Being conscious in this sense means the mind knows that a quale has occurred, can talk about it, and can send its information to various parts of the mind, as discussed before.) Accordingly, such awareness and experience will be specifically called conscious awareness and a conscious experience, respectively. They can be defined as follows:

Definition: Conscious awareness is awareness of what a quale is like.

Definition: A conscious experience is an experience of what a quale is like.

These are the general definitions of conscious awareness and a conscious experience.¹² However, frequently, we have to discuss these phenomena in a specific situation, for example, in awareness and experience of a specific quale, such as an image of a house, a sound of a song, or an odor of a flower. In such situations, we will use the phrases “*conscious awareness of*” and “*a conscious experience of*” to be specific. These phrases have identical definitions to their general definitions. That is, *conscious awareness of a certain quale is awareness of what that quale is like*, and *a conscious experience of a certain quale is an experience of what that quale is like*. For example, conscious awareness of an image of a house is awareness of what an image of a house is like, and a conscious experience of a sound of a song is an experience of what a sound of a song is like.

Next, there are several points to be noted about conscious awareness and a conscious experience. They are as follows:

First, as discussed above, when the mind is aware of and experiences something that is not a quale, some kind of awareness and experience of that thing’s existence occurs, but awareness and an experience of what that something is like do not. Therefore, *awareness and an experience of what something is like are not possible if that something is not a quale*. Accordingly, in valid cases, *awareness and an experience of what something is like* can only be awareness and an experience of what a quale is like, and *conscious awareness and a conscious experience of something* can only be conscious awareness and a conscious experience of a quale.

Second, it should be noted that awareness and an experience of what a quale is like always occur with awareness and an experience of the quale’s existence because it is not possible to be aware of and experience what a quale is like without simultaneously being aware of and experiencing its existence. Therefore, conscious awareness of a quale or awareness of what a quale is like always implies that there is concurrent awareness of the quale’s existence. A similar implication holds in the case of a conscious experience.

Third, because conscious awareness and a conscious experience always occur together and because we often discuss them together, to be concise, the term *conscious awareness and experience* will be used instead of *conscious awareness and a conscious experience* to refer to these two phenomena. Likewise, *conscious awareness and experiences* will be

¹² Various authors use the term *conscious experience* in this meaning [see References 5,7,16,24,62,68,101–105]. Other similar or closely related terms in the literature are *phenomenal experiences* [29,59,65,81] and *phenomenal consciousness* [5,13,16,19, 28,29,31,65, 81,106–110].

used instead of *conscious awareness and conscious experiences* when discussing awareness and experiences of several things. However, when emphasizing that they are two distinct phenomena or when discussing each specific phenomenon, complete terms will be used.

Fourth, when conscious awareness and experience occur, additional awareness and experience occur, which are awareness and an experience of the conscious awareness and experience that have occurred—we know that conscious awareness and experience have occurred and know what they are like. Hence, conscious awareness and experience themselves are consciously experienceable; they thus are qualia. Furthermore, because the mind can be aware of and experience what conscious awareness and experience are like, conscious awareness and experience, like other qualia, manifest what themselves are like in the mind, with manifestation uniqueness and ineffability. Thus, like other qualia, they have phenomenal characteristics or phenomenality.

Fifth, as any particular conscious experience, such as a conscious experience of an image quale of a house, occurs only in the mind of a subject who is having that experience, that experience is limited to that subject, and only that subject knows what that experience is like, such as what his or her conscious experience of the image quale the house is like. Although another subject can have a similar conscious experience, such as a similar conscious experience of an image quale of the same house, and know what it is like for himself or herself, he or she can never have the conscious experience of another subject. Thus, he or she can never know exactly what the conscious experience in another subject is like, such as what another subject's conscious experience of an image quale of the same house is like. Therefore, the conscious experience in each subject is exclusively limited to the subject who has the experience. Hence, in this sense, it is subjective. Consequently, a conscious experience may be called *a subjective experience* or *a subjective conscious experience* [6,7,13,51,103,104,111,112]. However, the author considers that the conscious part is essential for the experience to occur as a conscious experience instead of an unconscious experience, while the subjective part may exist in an unconscious experience as well (i.e., like a conscious experience, an unconscious experience is likely to be exclusively limited to the subject who has it—no one else will ever have access to the subject's unconscious experience) and thus may not help differentiate between a conscious experience and an unconscious experience. Therefore, in this theory, this kind of experience will be simply called a conscious experience.

Sixth, another important issue related to the term conscious experience is that, in the literature, the terms quale and conscious experience may be used interchangeably to mean *a mental phenomenon that is consciously experienceable* (such as an image quale of a house) or *a conscious experience of such a mental phenomenon* (such as a conscious experience of an image quale of a house). That is, in some literature, there is no distinction between the two terms and between the two phenomena, which can be

confusing. Thus, the reader has to be careful in assessing which phenomenon is being discussed in the literature and which meaning is being used for that term.

However, current knowledge in neurophysiology indicates that, although the two phenomena—a quale and conscious experience—are functionally closely related and sometimes overlap (as in the case of conscious awareness and experience, because both are also qualia, as discussed before), they are different phenomena [2]. All qualia except conscious awareness and experience occur with neural processes that are different from those of conscious awareness and experience, and these two kinds of phenomena can change independently of each other. For example, a visual quale of a house occurs with the visual perception neural processes in various visual perception areas, whereas the conscious experience of this visual quale (the experience of what the visual quale is like) occurs with the synchronization between the consciousness neural process and the visual perception neural processes that the visual quale occurs with [66,113–115]. Separate disturbances in the neural process that a quale occurs with without disturbances in the consciousness neural process, which a conscious experience occurs with, can occur, and vice versa. For example, when a person is consciously experiencing the visual, auditory, and olfactory qualia of the surroundings, if there is an acute stroke affecting the right occipital lobe, resulting in left hemianopia, the visual qualia will correspondingly be affected, but his or her overall conscious experience will still be intact, as evidenced by the fact that he or she can still consciously experience the auditory, olfactory, and remaining visual qualia normally. On the other hand, if the person becomes drowsy, his or her conscious experience will become weaker and weaker and may finally fade away, while the qualia themselves remain undisturbed; that is, the manifestations of the visual, auditory, and olfactory qualia are not disturbed. For example, no focal deficit or distortion in the visual, auditory, or olfactory qualia occurs. Therefore, in this theory, the two phenomena—qualia and conscious experiences—are two different phenomena and will be referred to by different terms:

- Only a quale, no other term, will be used for *a mental phenomenon that is consciously experienceable*, and a quale will be used to refer to only this phenomenon, nothing else. (Qualia will be used in plural cases.)

- Only a conscious experience, no other term, will be used for *an experience of what a quale is like*, and a conscious experience will be used to refer to only this experience, nothing else.

Lastly, one of the most important facts about conscious awareness and experience is that they do not occur with all mental processes. For example, they do not occur with any mental process in the basal ganglia, brainstem, cerebellum, or autonomic nervous system. We never have conscious awareness and experience of what happens there. For instance, we never know that we are sensing and controlling various blood constituent levels (e.g.,

sodium, oxygen, sugar, hormone, and coagulant levels) at all times to maintain homeostasis, and we never know what it is like to sense these blood levels and operate their controls; we never know that we are constantly sensing pressure in our vessels (arterial, venous, and lymphatic) and controlling the contraction of these vessels and the heart to maintain appropriate vascular pressure, and we never know what it is like to sense these vessels' pressure and operate their controls; we never know that we are sensing and controlling various reflexes (autonomic, gastrointestinal, myotatic, etc.) all over the body all the time to quickly and appropriately respond to various stimuli, and we never know what it is like to sense these reflex stimuli and operate these reflex controls.

Because conscious awareness and experiences are awareness and experiences of what qualia are like, they must occur with qualia. This means that they must occur with mental processes that have qualia as their products, which are the following:

C1. Mental processes in the final stages of all external sensory perception processes and of some internal sensory perception processes, such as those in the final-stage visual, auditory, olfactory, vestibular, and visceral-pain perception processes, which have mental images, sounds, smells, equilibrioception (sense of balance), and visceral pain as their qualia, respectively.

C2. Mental processes in the final stages of certain highest-level emotion-cognition-execution processes, such as those in the final stages of emotion-generating, thinking, planning, decision-making, and motor-commanding processes, which have emotions, thoughts, mental plans, decisions, and motor commands as their qualia, respectively.

Therefore, conscious awareness and experiences occur with these mental processes only. Conscious awareness and experiences do not occur with other mental processes, which will be discussed next.

3.5 Unconscious Awareness

For mental phenomena that are not consciously experienceable (or are not qualia), such as those occurring in the mental processes for perception and control of blood constituent levels, vessel pressure, and reflexes, as discussed in the previous section, even though the mind is aware of them in some ways and constantly responds to them accordingly, it is not aware of and does not experience what they are like, and conscious awareness and experiences of them do not occur. In this theory, when the mind is aware of a mental phenomenon in this way, the mind is said to be *unconsciously aware of* that mental phenomenon, and this kind of awareness will be called *unconscious awareness*. Regarding experiences, whether unconscious experiences (as the counterpart of conscious experiences) occur with unconscious awareness is debatable [13,116,117], and it certainly depends on how “unconscious experience” is defined. However, this potentially existing “unconscious experience” is not necessary for discussing the matter in this theory; thus, it will not be discussed further.

There are innumerable mental phenomena that the mind is unconsciously aware of, and unconscious awareness occurs for them. They make up the great majority of all mental phenomena and occur in the following mental processes:

UC1. Mental processes in a) the early stages of all sensory perception, b) all stages of non-sensory stimulus perception, and c) some special situations. Some examples are a) mental processes in the early stages of visual, auditory, and somatosensory perception, b) those in all stages of perception of blood constituent levels, vessel pressure, and reflex stimuli, and c) those that function for unconscious processes in the cases of binocular rivalry [51–58], subliminal perception [118–121], attentional blink [122–125], inattentional blindness [126–132], and blindsight [133–136]. We are not aware of and do not experience what something is like in these mental processes.

UC2. Mental processes in a) the cerebral hemispheres except those specified in C1 and C2 and b) all the other structures of the nervous system (the brainstem, cerebellum, spinal cord, and peripheral, autonomic, and enteric nervous systems). Mental processes in this group are countless. Some examples of them are those that function for unconscious attention, unconscious thinking, unconscious reading, unconscious visual perception and face recognition, unconscious mathematical operation, unconscious decision making, unconscious control of muscle tone and motor coordination, unconscious control of spontaneous breathing, unconscious control of cardiac functions and vessel contraction, unconscious control of blood constituent levels, unconscious control of gastrointestinal tract secretions and movements, and unconscious control of all reflexes [137–168].¹³ We are not aware of and do not experience what something is like in these mental processes.

3.6 Conscious Awareness vs. Unconscious Awareness

From the above discussion, it can be seen that conscious awareness and unconscious awareness are different in a behavioral aspect: The mind in the former but not in the latter case can report that something has happened and that it is aware of what that something is like. Thus, if a person has no condition that prevents him or her from giving correct reports (such as a language disability or paralysis of muscles for vocalization, eye movement, and gesturing), we can verify whether the person is having conscious awareness or unconscious awareness of something by asking the person if he or she knows that something has occurred in his or her mind and whether he or she is aware of what that something is like. The answer to both questions will be “yes” if the person has conscious awareness of that thing (such as a visual quale of a house, an auditory quale of a song, or an olfactory quale of a flower) but will be “no” if the person has unconscious awareness of that thing (such as perception of a blood sodium level, arterial wall pressure,

¹³ It should be noted, however, that the extent of the effects of some of these unconscious processes are still debated [169–173].

or reflex stimulus). However, if the person has conditions that prevent him or her from giving reliable reports, this kind of verification will not be possible or reliable.

Nevertheless, despite the above constraints, there is a special case in which an assessment of whether conscious awareness occurs or not is possible even though the person has conditions that prevent him or her from providing reliable reports. This special case occurs when an episodic stimulus, such as a flash of letters, pictures, or symbols, gains access into the conscious awareness system. Neurophysiologic experiments have revealed that, when such access happens and conscious awareness of that stimulus appears, the following neural phenomena occur [40,45,47,66,68,70,73,75,113,115,174–188]:

- a) a sudden, intense ignition of widespread neural activities, especially those of bilateral prefrontal and parietal regions,
- b) an appearance of a slow wave about 300–500 milliseconds (ms) after the stimulus onset, a P300 wave, over the vertex with bilateral spread over the prefrontal cortex,
- c) a massive increase in high-frequency gamma-band oscillation, starting around 150–300 ms after the stimulus onset, with later amplification of the activity, and
- d) a massive synchronization of electromagnetic signals across distant cortical regions, occurring late in the 300–500 ms time window.

There are also other neural phenomena that are found to correlate with conscious awareness, such as the firing of specific neurons (concept cells) in the medial temporal cortex [189,190], anterior temporal cortex, and prefrontal cortex [179]. In the future, as research about conscious awareness progresses, more neural phenomena may be found to occur with it. However, at present, it is not settled which combination of the reported neural phenomena is necessary and sufficient to indicate that this episodic kind of conscious awareness, which is usually called access consciousness or a-consciousness [9,13,16,31,106–109,191–193], has occurred. Nevertheless, this kind of conscious awareness is very likely associated with some specific combination of the reported neural phenomena, which is expected to be identified in the future. Finally, because episodic qualia induce occurrences of conscious awareness with appearances of these reported phenomena, a quale of an episodic stimulus should ultimately be able to be defined objectively as a mental phenomenon that can induce some specific combination of the reported neural phenomena.

Still, it must be emphasized that these neurophysiological findings mostly come from various kinds of studies in which a subject is assessed for responses to a small piece of episodic, external stimulus (a target in the experiment) presented to the subject in an experimental, non-natural setting. Hence, the findings and conclusions are valid only for such cases (subjects responding to similar episodic stimuli in comparable settings). What happens in daily life situations in which a conscious person is bombarded with myriad

external and internal stimuli of diverse kinds, sizes, and strengths concurrently and continuously remains unknown. Do all the reported neural phenomena (such as those in Items 1 to 4 above) occur together all the time? For example, when a person is walking in a bustling city center, do the P300 and other reported neural phenomena occur together all the time for all the stimuli (visual, sound, smell, etc.) that are bombarding him or her constantly and simultaneously? Alternatively, are some recently found neurophysiologic phenomena, such as rich functional dynamics of brain networks [194], better electrophysiological markers of conscious awareness in this daily life setting?

Finally, despite the exciting prospect of objectively identifying qualia and conscious awareness, it should always be remembered that, basically, a quale is a mental phenomenon that is consciously experienceable and that conscious awareness is awareness of what the qualia are like because these basic facts alone can help us identify their nature, as we will see in the following chapters.

3.7 Sensory Perception Qualia

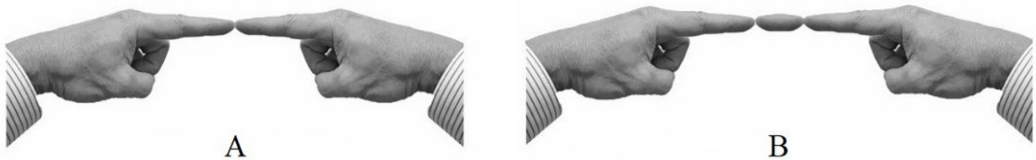
Before we end this introductory chapter of qualia, let us examine qualia of a specific type that are very important because they make us live not in the dark but in the world of fascinating phenomenality—the sensory perception qualia—to see what they do and are functionally.

A sensory perception quale of the outside world, such as a visual quale of a house, an auditory quale of a song, or an olfactory quale of a flower, may seem real, but it is not that physical thing. It is just a mental phenomenon of a sensory perception mental process, which occurs with a sensory perception neural process (Theorem I), to represent that thing [11,18,65,74,195,196]. However, the process of neural perception of the outside world depends on many factors, such as, in the case of visual perception of a house, *a) the external physical factors* (the light that illuminates the house, the medium through which the light passes, the distance between the house and the eyes, etc.), *b) the internal anatomical factors* (from the corneas to the retinae to the visual perception areas in the brain), and *c) the internal physiologic factors* (from the generation of visual signals in the retinae through several steps of signal processing in various visual perception neural processes to the final steps of signal processing in the final visual perception neural processes). Therefore, the final neural perception of the outside world and the associated mental perception and quale usually do not identically represent the outside world in detail but are just approximate and modified representations of it. Since the details of the neural perception and quale are the information about the outside world, the final information that is contained in the neural perception and the quale is not identical to that of the outside world. Sometimes, the inaccuracies produced in the perception may be so significant that they result in an illusion, or there may be a perception system anomaly

that causes a second, different perception to occur with the primary perception, resulting in a condition called synesthesia [197–201].

Some examples of qualia with inaccuracies in representing the outside world are as follows:

- The image quale of a house, when one looks at the house from a distance, does not contain the complete visual details of the house, such as the nails in the house walls, a patch of dirt on the door, or a small crack in a window. These inaccuracies result from an external physical factor (the distance) combined with an internal physiologic property (the limited spatial resolution of the retina). Thus, the image quale of a house is neither the physical house nor an exact representation of it.
- Various visual illusions occur physiologically in healthy people, such as the finger-sausage illusion in Figure 3.3.



A—The fingers as they appear when looked at directly

B—The fingers as they appear when one looks at the background behind the fingers

Figure 3.3 Finger sausage illusion

It can be seen that the image quale of the fingers (or the fingers as we see them in our minds) changes when the focus of the sight changes. However, the fingers themselves cannot physically change just by changing the sight's focus. This proves that the image quale of the fingers (or the fingers as we see them in our minds) is neither the physical fingers nor an exact representation of them.

– An auditory illusion quale of a third tone, a binaural beat, can be heard when two different pure-tone sine waves with frequencies lower than 1,500 Hz and less than 40 Hz difference between them are presented separately through each ear. This illusion is physiologically created in the auditory perception system [202–206]. Thus, the binaural beat quale does not represent anything that exists in the outside world.

– A color quale occurs with a sound quale when a person who has sound-to-color synesthesia hears a musical sound. This additional visual quale occurs because there is a neural connection anomaly between the auditory and the visual perception systems [207–209]. Thus, this visual quale is not a representation of anything that physically exists.

In representing the outside world, the inaccuracy of a neural process's perception and that of its associated quale involve all details of the outside world, including the temporal details, not only the non-temporal details, which have just been discussed. For example, in the case of visual perception of a house, it takes time from the moment the house reflects the light to the moment that the visual neural process creates perception and the visual quale of the house occurs. As a result, the visual quale of the house or the house we see in our minds does not represent the house in real time but the house about 300–400 ms in the past [66,113,176]. The temporal inaccuracy can be more obvious in cases of very distant objects. For example, when we look at the sun (safely using some solar filters), the sun we see in our minds does not represent a real-time sun but an 8-minute-ago sun. This kind of time aberration occurs for all other celestial objects: planets, stars, supernovas, etc.—some of them have even already vanished when we see them in our minds. Also, a temporal inaccuracy in qualia may arise physiologically from the work of neural processes themselves. An example is the prolongation of time that we feel in the stopped-clock illusion [210–213].

Moreover, we normally see, hear, taste, touch, etc. only in a limited spectral range and with a limited resolution. If we could perceive a certain sensation in a wider spectral range and with a finer resolution, the neural representation and the quale of that sensation would be different from what they are now. For example, if we could see things in almost the full spectral range of electromagnetic waves and with a resolution at the sub-atomic level, the visual neural representations and the associated visual qualia of those things would be drastically different from what we regularly experience, and the world would appear radically different from how it does now. Evidently, even though our current powerful electron microscopes and telescopes have not reached their maximal potential yet, things around us and the sky above us, when seen through them, have already appeared remarkably different from when seen through our unaided eyes. Thus, an interesting philosophical question regarding this matter is: Which spectral range and resolution would yield the most correct representation ... or does there exist such a perfect representation?

In summary, a sensory perception quale occurs with the function of a sensory perception neural process to represent a physical thing in the outside world, but it is not the physical thing itself [11,18,65,74,195,196,214–216]. As various factors affect the process of neural perception of the outside world, the details of the resulting neural perception and its associated quale are not identical to the details of the outside world. Thus, a sensory perception quale is just an approximate, modified representation of something in the outside world; illusion qualia and synesthetic qualia, which represent nothing real in the outside world, may also occur.

If qualia are just representations of things in the external world, what are those things really like by themselves?

By themselves, things in the external world do not have color, shape, sound, smell, hardness, etc. as they appear in our minds. They just have properties that can create mental phenomena that are consciously experienceable, or qualia, in a being's nervous system and mind via the being's sensory perception systems. These qualia represent those things in the forms of colors, shapes, sounds, smell, hardness, etc. in our minds. Qualia of something in the outside world may be different for different beings perceiving the same thing, but none of the qualia is that thing or can be claimed to be the only correct representation of that thing.

In Figure 3.4, neither the man, the woman, the dog, nor the bee can claim that his or her or its image quale of the house is the house or that his or her or its image quale of the house is the only one that is the correct representation of the house and that the others' image qualia are incorrect representations. Also, it should be noted that, because it is not known what the correct visual representation of the house is or even whether it exists, it cannot be illustrated in the figure but can only be represented by the word "House."



Figure 3.4 Image qualia of the same thing among different subjects

Similarly, perceptions of space, time, and existence are not what space, time, and existence are either. The former entities are just mental phenomena that are created to represent the latter entities, but they are not the same things. Thus, fascinatingly, our space, time, and even *our existence* as we feel them are not what they really are. So, what are they really? The answer is that we will probably never know because we can know what things are only through our neural processing systems, but we can get only representations of those things through neural processing systems. Our minds do not have the ability to directly know things in the outside world by themselves.

Lastly, what things in the outside world, space, time, and existence are like by themselves is an unanswerable question because what those things are like is not absolute but observer-dependent. When there is no observer to judge what they are like (i.e., in the

question of what they are like by themselves), the question of what they are like is meaningless.

3.8 Remarks

This is a long chapter that involves many definitions of specific terms. The most important of them are the definitions of a consciously experienceable mental phenomenon, quale/qualia, conscious awareness, and a conscious experience. These definitions are very crucial because they establish what exact phenomena this theory investigates, which is indispensable for correct understanding, future applications, and comparisons with other theories.

The next chapter (Chapter 4: Theorem III) will examine and determine whether qualia are physical phenomena, and the subsequent chapter (Chapter 5: Theorem IV) will investigate and find the nature of qualia and answer the hard problem of qualia, the explanatory gap, and other related questions.

Chapter 4

Theorem III: Qualia are Physical Phenomena

Qualia are mental phenomena that are consciously experienceable, and we have learned some of their important characteristics, as discussed in the previous chapter. However, many questions about them remain. The most important ones are whether these phenomena are physical or non-physical, what they are physically and ontologically, and why and how they occur.

Regarding the first question, some think that qualia are non-physical phenomena—happening without physical rules, such as unpredictably occurring in some people but not in others and arbitrarily occurring in one form in some people but in other forms in others. This kind of thinking leads to the concept of a p-zombie, which is defined as “a being that is physically identical to a human but lacks qualia and consciousness,” and the conjecture that there may be p-zombies living among us; that is, some of us may not have qualia and consciousness in their minds even though they behave completely like us [1–23]. It also leads to the concept of variable qualia, which are qualia (of the same things) that vary in their manifestations among people—for example, qualia of a certain color may appear as red in some people but as blue or green or other colors in other people [12,24–28]. On the contrary, some believe that qualia are physical phenomena, governed and predictable by some physical rules and occurring consistently and similarly among people.

This chapter attempts to find the answer to the first question—the question of whether qualia are physical phenomena. The second and third questions—the questions of their physical and ontological nature and the causes and mechanisms of their occurrences—which are more difficult to answer, are investigated in the next chapter.

4.1 Physical Properties of Qualia

Like mental processes, qualia have many properties. Some are physical properties, which are properties that are directly related to the physical world and can be investigated physically; some are functional properties, which are properties that are related to qualia's functions, such as being ineffable, intrinsic, and private [12,19,22–24,28–30]; being irreducible [19]; being directly or immediately apprehensible in consciousness [30]; and various other functional properties [31,32]. However, to determine whether qualia are physical phenomena and what qualia are physically and ontologically, it is necessary to examine their physical properties.

Qualia, as defined in Section 3.1, have many physical properties. Ten of them that this theory considers important and helpful in identifying the nature of qualia are as follows:

Physical properties of qualia (PQ)

PQ1. Defining physical properties

PQ1.1 They are mental phenomena.

PQ1.2 They are consciously experienceable.

PQ2. Additional physical properties

PQ2.1 Their existence is restricted to their neural processes.

PQ2.2 Their existence with their neural processes is consistent.

PQ2.3 Their manifestations are diverse and represent something.

PQ2.4 Their manifestations match their neural processes’.

PQ2.5 Their chronological aspects match their neural processes’.

PQ2.6 Their structures are definite.

PQ2.7 Their structures are determined by their neural processes.

PQ2.8 Their interactions are via their neural processes.

PQ1. Defining physical properties

Defining physical properties are physical properties that we believe things that should be called qualia should have and that we use in their definition. They are as follows:

PQ1.1 They are mental phenomena.

This is in the definition of a quale (Section 3.1)—*a quale is a mental phenomenon that is consciously experienceable*. If we verify this property, we find that it is valid to our intention because we never find a non-mental phenomenon that is called or should be called a quale.

Because qualia are mental phenomena (phenomena of the mind) and because the mind is non-material and coexists with the brain (Theorem I), qualia must be *non-material phenomena and coexist with the brain*. This physical property will help us determine the exact nature of qualia in the next chapter.

PQ1.2 They are consciously experienceable.

This is also part of the definition of a quale. If we verify this property, we find that it is valid to our intention because we never find a mental phenomenon not consciously

experienceable (such as perception of the blood level of sodium, pressure in vessel walls, or autonomic reflexes) that is called or should be called a quale. This property is one of the most important physical properties of qualia. It will help us identify what qualia are physically, so let us investigate it in detail.

When we analyze this property, we find that it requires a quale to have the following three physical properties: A quale must

1. be readable by the consciousness neural process,
2. be able to induce awareness and an experience of what itself is like in the consciousness neural process, and
3. be information about what itself is like.

These three properties are derived as follows:

1. As discussed in Section 3.1, for a quale to be consciously experienceable, the mind must be able to be aware of and experience what the quale is like (what an image quale of a house is like, what a sound quale of a song is like, what an odor quale of a flower is like, etc.). According to Theorem I, this is possible only if some neural process can be aware of and experience what the quale is like, which means that the quale must be readable by this neural process so that the neural process can be aware of and experience what the quale is like. In this theory, the neural process that functions to be aware of and experience what mental phenomena are like and create awareness and experiences of what they are like is called ***the consciousness neural process***. Therefore, a quale ***must be readable by the consciousness neural process***.

2. Because awareness and an experience of what a quale is like occur when the mind is aware of and experiences what the quale is like, a quale ***must be able to induce awareness and an experience of what itself is like in the consciousness neural process***.

3. Because awareness and an experience of what a quale is like occur, a quale ***must be information about what itself is like*** so that, after the consciousness neural process reads the quale, it can have the information about what the quale is like and use this information to create awareness and an experience of what the quale is like. For example, an image quale of a house must be information about what the image quale is like so that after the consciousness neural process reads the quale, it can use the information to create awareness and an experience of what the image quale of the house is like. Otherwise, the consciousness neural process would lack the needed information to create awareness and an experience of what the quale is like.

Therefore, for a quale to be consciously experienceable, it must have these three properties. Similarly, anything that proves to be a quale must also have these three properties. In the next chapter, these properties will help us identify the nature of qualia.

PQ2. Additional physical properties

Additional physical properties are physical properties that qualia are observed to possess in addition to their defining properties. They are as follows:

PQ2.1 Their existence is restricted to their neural processes.

Because qualia are mental phenomena, they exist with mental processes. Because mental processes coexist with their neural processes (Theorem I), qualia also coexist with neural processes. However, as qualia exist only with some mental processes (Section 3.3), qualia exist only with some neural processes, called *qualia's neural processes*. These neural processes are those involved in the final stages of sensory perceptions (such as the final visual perception neural processes and the final auditory perception neural processes) and those involved in the final stages of some highest-level emotion, cognition, and execution processes (please see C1 and C2, Section 3.4). These neural processes are exclusive to the latest-evolved parts of the brain. This *selectivity* indicates that some specific characteristics of these neural processes must be the factors that enable them to be associated with qualia. Also, the fact that qualia occur selectively in the latest-evolved parts of the brain instead of the more primitive parts of the brain (such as the basal ganglia, brainstem, and cerebellum) or randomly all over the whole nervous system indicates that certain evolutionary processes were involved in this selectivity. Thus, it is probable that some characteristics of neural processes, such as unique neural circuitries or special processing processes, have evolved for qualia to occur and coexist with them.

Moreover, the occurrences of each kind of quale are specifically fixed and limited to a certain kind of neural process. For example, visual qualia (color, brightness, shape, etc.) occur only with visual perception neural processes (those in the visual cortices) and never occur with other neural processes (those in other brain areas); vice versa, only visual qualia, not any other types of qualia (e.g., auditory, somatosensory, and emotion), occur with visual perception neural processes. This *specificity* can be demonstrated using techniques such as fMRI, MEG, ECoG, and intracortical and single-unit recordings. For example, when a subject reports an occurrence of a visual quale, neural processes only in the visual cortices will be found to become active; when the subject reports the disappearance of that visual quale, these processes will be found to become inactive; conversely, when the neural processes in the visual cortices are stimulated to become active, such as by electrical or magnetic stimulation, only visual qualia, not other kinds of qualia, will be reported to occur. This kind of specificity is also true for all other kinds of qualia. Therefore, some specific characteristics of neural processes must be the factors that determine which type of quale (visual, auditory, olfactory, etc.) occurs with which kind of neural process.

In summary, the restrictions in where qualia can exist have the following features:

- Which neural processes have qualia, or where qualia occur and exist in general, is determined by some neural process characteristics (the selectivity).
- Which specific neural process a certain kind of quale (visual, auditory, olfactory, etc.) occurs and exists with, or where specific types of qualia occur and exist, is also determined by neural process characteristics (the specificity).
- These characteristics are probably the result of neural-process evolution.

Thus, qualia's existence is not random but restricted to some specific neural processes, called qualia's neural processes.

PQ2.2 Their existence with their neural processes is consistent.

Another cardinal characteristic of qualia's existence is its **consistency**. Qualia not only specifically but also consistently occur and exist with their neural processes. For example, whenever we open our eyes to experience visual qualia of the outside world, if the visual perception neural processes and other parts of the visual system function normally, the visual qualia always occur and continue to exist as long as our eyes stay open. We never experience episodes of perception with visual qualia alternating with episodes without visual qualia while we open our eyes.

The consistency of qualia's occurrences and existence extends across time and biological changes. For example, visual qualia have always occurred whenever we open our eyes since we were babies up until now, even though our visual neural processes have been changing biologically throughout time (and we now are quite different biological entities from those we were as babies). It never happened that, at times in our lives, we did not have visual qualia when we opened our eyes, yet we were able to go about not hitting things in the way, describe the appearances of things we saw accurately, and interact with them correctly. Similarly, this consistency in occurrences and existence is true for all other kinds of sensory perception.

At this point, it should be noted that blindsight [33–37] and chromatic blindsight [38], the conditions of persons seemingly having visual perception without conscious visual perception, i.e., without visual qualia occurring, are not evidence that visual qualia do not consistently occur, because people with blindsight or chromatic blindsight have abnormalities in their visual perception neural processes. Hence, there is no contradiction to the above-stated consistency, which holds under normal circumstances. Specifically, it means that qualia consistently occur and exist with their normal neural processes; when their neural processes are abnormal, qualia possibly do not occur. Moreover, it should be pointed out that perception in these abnormal situations, in which qualia do not occur, is not as good as perception in normal situations, in which qualia occur—they have less detail and are of poorer quality.

The consistency of qualia's occurrences and existence extends across people and places as well. For example, people with normal visual systems everywhere always have

visual qualia when they open their eyes. It is not the case that some healthy people do not have visual qualia, but some do. This is evident from the fact that all healthy people can comprehend the meaning of the term “visual qualia,” which means they can relate the term to some of their previous mental experiences. People who never experience visual qualia would not have information about visual qualia in their minds, would not be able to associate the term “visual qualia” with anything they have experienced, and thus would not know what the term “visual qualia” refers to. They would surely be surprised when learning that other people have something they do not. Some of them would likely question what other people are talking about, what visual qualia are like, why they do not have them, and so on. Philosophers and neuroscientists who do not have qualia would certainly report the absence of qualia in their minds to the scientific community and formally establish in the literature that some healthy people, such as them, do not have qualia. They would definitely not engage in discussing this matter or participate in conferences, research, or experiments about this matter seriously as if they had these phenomena. This matter is also conversely true for us. If some people said that they had qualia of the perception of blood level of sodium and other blood constituents or if they were discussing these qualia or having conferences, doing some research, or conducting experiments about them, we would be surprised. We would undoubtedly not engage in discussing those qualia knowingly with them or participate in those conferences, research, or experiments seriously as if we had the qualia. Instead, we would tell them that we did not have those qualia and would ask them many questions about the qualia, such as what their characteristics were.

Some people who do not have visual qualia would probably seek medical advice. This actually happened—a patient with cerebral achromatopsia from a stroke sought medical attention because of a colorless sight (a sight without perceivable color qualia) even though he still had subconscious color perception (i.e., he was able to describe the colors of objects correctly above chance to some degree even though he denied perceiving those colors) [38]. In this patient, the absence of visual qualia occurred from the absence of the color perception neural process. This case confirms that, when one lacks visual qualia, one does seek medical advice because of the deficit. Yet, clinically, there are no medical records about people with normal visual systems who lacked or lost visual qualia. This non-existence of such records has been true for several hundred years or more. Therefore, it can be concluded that the absence of visual qualia in people with normal visual systems never occurs and that visual qualia consistently occur in people with normal visual systems. This kind of consistency is also true for other types of qualia.

To summarize, in healthy people, qualia consistently occur and exist with their neural processes. This consistency indicates that qualia’s occurrences and existence are not haphazard but are strictly determined by some characteristics of their neural processes.

PQ2.3 Their manifestations are diverse and represent something.

Qualia's manifestations are diverse in type. For example, they can manifest as visual, auditory, olfactory, emotion, or thought qualia. Notably, various types of qualia manifestations are categorically different from each other. Moreover, each type is infinitely diverse in details, complexity, and dynamicity. For example, visual qualia can vary from those of static, plain color screens to those of newspaper pages to those of lively scenes in a bustling city center, and auditory qualia, from those of soft, monotonous sounds to those of people's conversations to those of noisy, crowded music concerts.

Importantly, qualia's manifestations represent something. For example, a visual quale of a house represents the visual aspect of the house; a sound quale of a song represents the auditory aspect of the song; an odor quale of a flower represents the olfactory aspect of the flower; an emotion quale of happiness represents one agreeable kind of feeling; and a thought quale of something represents a mental cognitive activity of that thing.

Thus, anything that proves to be qualia must be able to manifest itself diversely in types and details and must represent something.

PQ2.4 Their manifestations match their neural processes'.

Qualia's manifestation details, ranges, and changes are not random but match those of their neural processes.

Qualia's manifestation details, such as color, brightness, shape, dimension, and movement of all points in a visual quale; pitch, timbre, loudness, formant, and attack of all sounds in an auditory quale; and types and strengths of an olfactory quale, are not haphazard but match those of their neural processes. If this is not the case, then qualia's details that are not those of their neural processes will be found to exist. For example, when people look at a house without anything around it, they may see a car in front of it, even if the image of the car is neither created in the neural process from normal seeing nor from some abnormal processes, such as illusion or hallucination. However, these kinds of strange phenomena never happen.

Qualia's manifestation ranges, such as the frequency and amplitude ranges of visual and auditory qualia and the spatial ranges (visual field) of visual qualia, are not random or unlimited but match those of their neural processes. If this is not the case, then qualia in the ranges outside those of their neural processes will be found to exist. For example, there will be visual qualia occurring outside the neural process's visual field (such as in the visual field covering the area behind the head), or there will be auditory qualia occurring below or above the frequency ranges of the auditory neural processes (such as in the infrasonic or ultrasonic range). However, qualia in such excess ranges never occur. Thus, qualia's manifestation ranges match those of their neural processes.

Regarding changes, whenever the manifestation details of their neural processes change, those of the qualia change accordingly and simultaneously. For instance, when

one looks around, resulting in new visual information in the visual neural process, the details of the visual qualia's manifestations will change accordingly and simultaneously—they cannot remain unchanged or change to those of another visual scene that one is not viewing. Another example is that, when there is a lesion in the ventral or caudomedial occipitotemporal or ventromedial occipital cortex, color-perception neural processes in these areas, as well as the perceived color information of the opposite visual field, will be impaired. Consequently, the qualia in the opposite visual field will inescapably lack color information, resulting in achromatopsia (color blindness) in that visual field [39–42]—they cannot still retain their color components. On the other hand, if their neural processes do not change, qualia cannot change. For example, when one stares at a house, an image quale of the house will remain the same as long as one keeps looking at the house; it cannot change to a quale of something else, such as a car, a tree, or an animal, even if the mind tries to change it. Therefore, when there is no change in their neural process, qualia cannot change, but when there is a change in their neural process, qualia cannot resist the change and must change similarly and simultaneously.

Therefore, qualia's manifestations match those of their neural processes.

PQ2.5 Their chronological aspects match their neural processes'.

Qualia's chronological aspects, which are the time they occur, represent things, and disappear, are not arbitrary but match those of their neural processes. Specifically, qualia do not occur or represent things in real time but in a time-lag manner corresponding to their neural processes' processing time. For example, when our foot hits something hard, the dull, aching pain quale does not occur immediately but is delayed for about hundreds of milliseconds to a few seconds. The delayed time equals the time it takes for the injury signal to travel to the brain and get completely processed, resulting in the dull, aching pain quale. Thus, the quale represents the impact's effect on the foot about a second in the past, not in real time. Another example is that a visual quale of a house represents the visual aspect of the house not in real time but about 300–400 ms ago [43–45]. This delay correlates with the time the visual perception system takes to process the visual signal to form the image. Similarly, all other visual qualia and all auditory qualia represent visual and auditory events not in real time but in a time-lag manner that depends on their neural processes' processing time (with significant additional signal traveling time outside the body in the case of auditory events).

The time a quale disappears also matches the time its neural process ceases functioning. When the neural process does not end its processing, the quale cannot disappear. For example, when we look at a bright lamp and then close our eyes to see nothing, we will keep seeing an afterimage quale even if we do not want to. This quale can disappear only when its neural process stops creating the afterimage. Similarly, when we stop spinning around, we will continue to have a quale representing the feeling of

spinning for a while. This quale will persist until its neural process stops creating this feeling.

Summarily, qualia's chronological aspects match those of their neural processes.

PQ2.6 Their structures are definite.

Another cardinal characteristic of qualia is that their structures are definite—that is, each type of quale has the same structure across people.

The structure of any type of quale consists of

1. the number and types of basic components of that type of quale and
2. the spectral characteristics of that type of quale.

The number and types of basic components of any type of quale are always definite. For example, *visual qualia* always have the following five basic components: color, brightness, shape, dimension, and movement; *auditory qualia* always have the following eight basic components: pitch, loudness, timbre, formant, attack, sustain, decay, and release; and *olfactory qualia* always have the following two basic components: odor type and strength. It should be noted that these are the number and types of basic components in humans. In other animals, they may be different. For example, animals that can perceive the polarization of light, such as some species of insects, cephalopods, and fish [46–50], may also have polarization as a basic visual component.

Also, it is essential to note that the number and types of basic components of each type of quale may vary according to how they are classified, which depends on the opinions of the authors. For example, some may include acuity as a basic visual component; thus, the number of basic visual components would be six; some may consider formant, attack, sustain, decay, and release as already included in the timbre; thus, the number of basic auditory components would be only three. However, the point here is the definiteness of the number and types—they are the same across all people. For example, if the correct number of basic components for visual qualia is five, it is five across all people—not four in some, five or six in others, and so on—and the types of basic components for visual qualia, whatever they are, are the same across all people.

The spectral characteristics of any type of quale are likewise definite. For example, when people see the light spectrum, the associated color-qualia spectrum in the mind will be as shown (as two identical spectra) in Figure 4.1. The two spectra always have definite spectral characteristics, such as where color qualia change their hues along the spectrum (e.g., color qualia always change their hues markedly at wavelengths around 410, 470, 490, 570, and 610 nm—see the upper spectrum) and definite relations between color qualia at different wavelengths (such as color qualia at wavelengths 380 and 440 nm [60 nm apart] are clearly different in their hues, whereas those at wavelengths 660 and 720 nm [also 60 nm apart] are quite similar in their hues—see the lower spectrum).

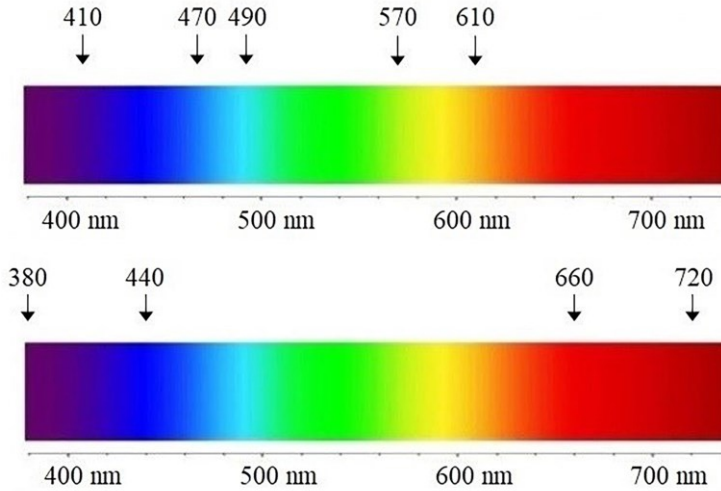


Figure 4.1 Two color-qualia spectra of the light spectrum

Another example is the pitch-qualia spectrum of a musical scale below. The spectrum also has definite spectral characteristics. At every doubling or halving of a sound frequency along the scale, pitch qualia will sound similar but one octave higher or lower, respectively. For example, please see Figure 4.2, C₄, C₅, and C₆ have pitch qualia that sound similar to human ears (but in different octaves).

C₄ D₄ E₄ F₄ G₄ A₄ B₄ C₅ D₅ E₅ F₅ G₅ A₅ B₅ C₆

Figure 4.2 A pitch-qualia spectrum from C₄ (261.63 Hz) to C₆ (1046.50 Hz)

Accordingly, although we cannot be certain whether other people experience the same visual or auditory qualia as we do (e.g., whether other people experience our red as red or as blue or some other colors or experience our note C as note C or as note G or some other notes), we can be certain that the qualia structure of each type of quale is the same across people (that is, the number and types of basic components and the spectral characteristics of visual, auditory, and other qualia in the reader, the author, and other people are the same), because if it were not, we would be able to observe that we had different experiences of the qualia. However, except for slightly different experiences due to somewhat different perception systems in different people or different experiences due to pathological conditions (such as color blindness, presbycusis, or parosmia), different experiences of qualia among healthy people have never been observed. Different places and times do not result in different experiences either. Therefore, the qualia structure of each kind must be definite and the same across all healthy people, places, and times.

It is also important to note that the structure of each type of quale is not only definite but also remarkably unique and different from those of other kinds. Firstly, the number of basic components of each type of quale is different from those of other types. For example, the number of basic components of a visual, auditory, and olfactory quale is five, eight, and two, respectively. Secondly, their spectra are strikingly different from each other. For instance, the pitch qualia of a chromatic scale in equal temperament do not exhibit irregular changes in pitch or loudness along the scale as the color qualia of a light spectrum do in hue and brightness along the spectrum, even though both qualia have similar regularly changing wavelength or frequency patterns along the scale or spectrum. Also, the color-qualia spectrum does not exhibit repeated similar hues at every double frequency along its spectrum as the pitch-qualia spectrum does in pitch along its scale. Remarkably, different kinds of qualia are able to maintain their structural uniqueness and thus keep their differences from other kinds consistently across billions of people in all places and at all times. This strongly indicates that qualia's manifestations are not haphazard but are determined by some physical rules. Otherwise, qualia's manifestations would be haphazard—occurring with different numbers and types of components and with different spectral characteristics in different people. (This interesting matter will be investigated in more detail in Extra Chapter II: Variable qualia.)

PQ2.7 Their structures are determined by their neural processes.

Evidence in neuroscience indicates that *the number and types of basic components* of each qualia type are determined by *the number and types of basic-component neural processes* of that qualia type. For example, the number and types of visual qualia's basic components (color, shape, direction, etc.) are determined by the number and types of basic-component neural processes of visual qualia. These basic-component neural processes function for perception of color, shape, direction, and other visual qualia components. The spectral characteristics of the qualia are also determined by the corresponding neural processes. For example, the spectral characteristics of color qualia and pitch qualia are determined by the color perception neural process and the sound frequency perception neural process, respectively. If these neural processes are affected, the qualia's spectral characteristics will also be affected [51–62]. Therefore, qualia's structures are determined by their neural processes.¹⁴

¹⁴ A similar notion has been presented in the literature before: Chalmers (1995, 1996, 1997) called this kind of correspondence between mental states and physical states “structural coherence” [63–66], and Velmans (2002) said that “for every discriminable attribute of experience, there will be a distinct, correlated, physical state. As each experience and its physical correlate represent the same thing, it follows that each experience and its physical correlate encodes the same information about that thing. That is, they are representations with the same information structure.” [67].

PQ2.8 Their interactions are via their neural processes.

Qualia cannot interact with mental processes or other qualia directly—they have to interact via their neural processes and connections. For example, the red color quale cannot directly interact with the consciousness mental process to create a conscious experience of the quale—it has to interact with the consciousness mental process via its neural process, the connection between its neural process and the consciousness neural process, and the consciousness neural process. This is evidenced by the fact that, if there is a lesion that destroys either of the neural processes or the connection between them, a conscious experience of the red color quale will not occur, even if the red color quale may have occurred.

4.2 Theorem III

The eight observable, additional physical characteristics discussed above are the same for billions of people everywhere, at present and in the past. The fact that qualia have identical characteristics across countless people and across unlimited time and places indicates that qualia are not arbitrarily occurring phenomena but must be phenomena governed by some physical rules that cause them to always occur with the same characteristics. That is, qualia must be physical phenomena. Moreover, because the characteristics discussed above are closely associated with their neural processes, which are physical processes and predictable by physical laws, these characteristics are also predictable by physical laws. Therefore, it can be concluded that qualia are physical phenomena—phenomena that are governed and predictable by physical laws—that are associated with their neural processes in the aspects that have been discussed. This theory asserts this conclusion as Theorem III:

Theorem III: Qualia are neural-process–associated physical phenomena.

The above is the specific form of Theorem III. The basic form can be stated as:

Theorem III: Qualia are physical phenomena.

This means that mental phenomena that are consciously experienceable, such as an image of a house, a sound of a song, and an odor of a flower, in our minds, are physical phenomena. They occur under physical rules, are predictable, and are associated with neural processes.

4.3 Predictions

1. All qualia's characteristics (such as occurrence, existence, location, structure, and information) will always be predictable by some physical laws.

2. A quale (such as a visual quale of a house, an emotion quale of happiness, or a thought quale of oneself) will be found to occur and exist with a certain neural process (such as the visual-perception, the emotion-generation, or the thought-formation neural process)—it will not be found to occur without a certain neural process. This means that, when and where there is a quale, the neural process that the quale is associated with will be found then and there.

Note. A neural process can be identified as the associated neural process of the quale by investigations that observe and may also manipulate potential neural processes concurrently with observing the quale. In various investigations, the neural process that consistently changes concomitantly and correspondingly with the quale will be that neural process.

3. For a paired quale and neural process as so identified, every event in the quale (such as an event in a dynamic visual quale of a movie, a dynamic emotion quale of alternating happiness, sadness, and indifference, or a dynamic thought quale of a complex deliberation) will be found to be associated with an event in the neural process (such as an event in a neural process in the occipital cortex, amygdala, or frontal lobe)—it will not be found to occur without a corresponding event in the neural process.
4. For a paired quale and neural process as so identified, the predictions that are valid for the neural process in an event or experiment, such as whether the neural process will occur, change, or stop functioning, will be valid for the quale.

All the above predictions can be verified by experiments in conscious, communicative human subjects. A typical experiment is to monitor a quale's occurrence, existence, change, etc. by having the subject report what happens to the quale in his or her mind while concomitantly monitoring the neural process by methods such as fMRI, MEG, ECoG, intracortical and single-unit recordings, and quantitative EEG and while the subject's neural process is being manipulated by methods such as drug administration, transcranial magnetic stimulation, or transcranial electrical stimulation.

4.4 Remarks

The concept that qualia are physical phenomena is not new. Although this idea was not explicitly stated, many scientists conducted their research and developed their theories regarding qualia based on this concept, as is evident from their methodologies. Furthermore, several theories concerning qualia conclude that they are some forms of physical entities (for instance, see References 68–77). Nonetheless, there has never been a theory that explicitly proves and methodically establishes that qualia are physical phenomena, governed and predictable by physical laws, and are associated with some neural processes. To the author's knowledge, this theory is the first one that does so.

However, there are still crucial questions to solve. What is qualia's physical and ontological nature, and why and how do they occur? These puzzles will be investigated and answered in the next chapter.

*If qualia were not physical phenomena,
manifesting arbitrarily without physical rules,
their appearances would be haphazard.*

*For visual qualia, some people would see only shapes,
while others would see only colors,
yet others would see only brightness,
or other random combinations of visual attributes.*

*Such strange inconsistencies never occur.
Qualia manifestations are consistent.*

*They must be physical phenomena,
manifesting under some physical laws.*

Chapter 5

Theorem IV: A Quale is a Signaling Pattern

From the previous two chapters, it can be concluded that qualia are non-material, neural-process-associated, physical phenomena. This chapter will answer the other major problems about them: What is the nature of these phenomena—what are they physically and ontologically—and why and how do they occur? At present, there are several theories about what qualia are and how they occur [1–10]. However, none of them seems to be unanimously accepted as conclusive, and none seems to be able to bridge the explanatory gap of how non-material, phenomenal qualia can arise from material, phenomenon-less (i.e., phenomenality-less) neural processes in the brain [11–27] and satisfactorily answer the hard problem of qualia, or the problem of why and how qualia occur [28,29]. This theory finds that the answers to these questions exist in the qualia's physical properties, which have been discussed in detail in the previous chapter and will be used to find the answers in the following sections.

5.1 The Nature of qualia

Because qualia are non-material, neural-process-associated physical phenomena, there are two mutually exclusive possibilities of how a quale exists in relation to neural processes:

Possibility I. A quale functionally exists separately (occurring and functioning separately) from all neural processes, similar to a separate-from-the-brain entity commonly illustrated in general pictures that depict qualia, such as an image quale of a house, a sound quale of a song, or an odor quale of a flower in Figure 5.1.



Figure 5.1 Qualia exist as separate entities.

Hence, its functions and effects are separate from those of all neural processes, even though it is somehow associated with its neural process in various aspects, as discussed in the previous chapter, by some mechanisms.

Possibility II. A quale functionally exists intrinsically (occurring and functioning intrinsically) in a certain neural process, called the quale's neural process, similar to different information that exists intrinsically in different signaling of the sign language in Figure 5.2.

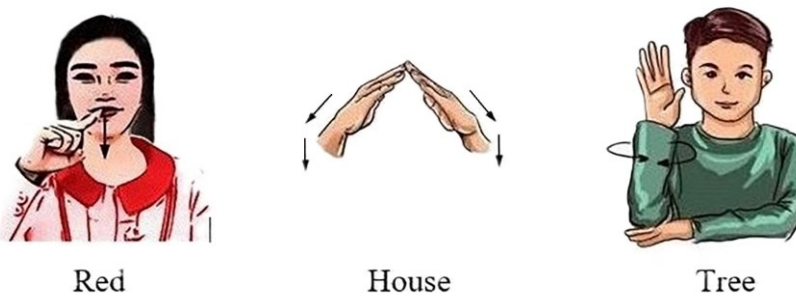


Figure 5.2 Information exists as intrinsic entities.

Hence, its functions and effects are naturally inherent in its neural process's functions and effects, and it is naturally associated with its neural process in all aspects.

Now, similar to the case of finding the nature of mental processes in Chapter 2, the means of identifying which possibility is correct is to examine the physical properties of the proposed entity in each possibility. It is based on the principle that the entity that a quale is must have all the physical properties of qualia. These properties are listed here again for ease of reference:

Physical properties of qualia (PQ)

PQ1. Defining physical properties

PQ1.1 They are mental phenomena.

PQ1.2 They are consciously experienceable.

PQ2. Additional physical properties

PQ2.1 Their existence is restricted to their neural processes.

PQ2.2 Their existence with their neural processes is consistent.

PQ2.3 Their manifestations are diverse and represent something.

PQ2.4 Their manifestations match their neural processes'.

PQ2.5 Their chronological aspects match their neural processes’.

PQ2.6 Their structures are definite.

PQ2.7 Their structures are determined by their neural processes.

PQ2.8 Their interactions are via their neural processes.

Next, let us examine the two possibilities to see which one yields an entity that has all the stated physical properties of qualia.

5.1.1 Possibility I: A quale is a functionally separate entity.

Suppose a quale is an entity Q that functionally exists separately from all neural processes, as shown in Figure 5.3.



Figure 5.3 Q functionally exists separately from all neural processes.

PQ1.1 Q is a mental phenomenon.

As discussed in PQ1.1 in the previous chapter, this property means that Q is a non-material phenomenon that coexists with the brain. Theoretically, Q can be a non-material phenomenon simply by its nature. But if it functionally exists separately (occurring and functioning separately) from all neural processes, then how can it appear to coexist with the brain? Another crucial question is: What is this entity, physically and ontologically?

If we try to find the answer to these questions, we will find that, indeed, there are phenomena that are non-material and functionally separate from all neural processes but still coexist with the brain. They are numerical (not physical, which is material) changes in quantities of a) metabolic activities (e.g., heat generation, oxygen consumption, and intracellular biochemical reactions), b) regional blood circulation (e.g., regional blood volume and flow rate), or c) physical components (e.g., mass, energy, and entropy) of

their neural circuits. However, these numerical changes can only increase or decrease in value in all kinds of neural processes. Thus, they do not possess sufficient variations to function variedly enough to be various types of qualia—image, sound, taste, emotion, thought, etc.—in different kinds of neural processes. Therefore, a quale cannot be any of these numerical changes, and the entity that a quale is, Q, which has this property, must be a novel, non-material entity. This necessitates a new hypothesis for its nature.

PQ1.2 Q is consciously experienceable.

As summarized in section PQ1.2 in the previous chapter, this property means that Q must

1. be readable by the consciousness neural process,
2. be able to induce awareness and an experience of what itself is like in the consciousness neural process, and
3. be information about what itself is like.

We can verify these properties are as follows:

1. Q must be readable by the consciousness neural process. However, if Q functionally exists separately from all neural processes, there will be no functional connections between Q and any neural process, including the consciousness neural process. Hence, the problem is how Q can be readable by the consciousness process. A new hypothesis is needed to account for this property.
2. Q must be able to induce awareness and an experience of what itself is like in the consciousness neural process. Again, the same problem is how Q can do so if Q has no functional connections with the consciousness neural process. A new hypothesis is needed to account for this property as well.
3. Q must be information about what itself is like. However, if Q functionally exists separately from neural processes, how and where can it get raw information to form the information about “what itself is like”? For example, if Q is an image quale of a house or a sound quale of a song, as depicted in Figure 5.3, how and where can it get information about the house or the song to form the information about “what the image of the house is like” or “what the sound of the song is like”? For Q to have this information, it certainly needs to have access to the raw information about the image of the house or the sound of the song in the first place so that it can use it to form the information about “what the image of the house is like” or “what the sound of the song is like.” However, if Q has no functional connection with neural processes, it cannot get the raw information from the outside world via neural processes. If Q gets the necessary information directly from the outside world, how can it do that? That is, how can the outside world send the needed information (about images, sounds, smells, etc.), all of which are carried by physical carriers

(electromagnetic waves, sound waves, odorant molecules, etc.), to Q, and how can the non-material Q receive these physical signals (e.g., with what receptors and with what mechanisms)? Thus, a new hypothesis is needed to explain where and how Q gets the required information from the outside world.

Therefore, for Q, an entity that functionally exists separately from neural processes, several new hypotheses must be established to explain how it can be consciously experienceable.

PQ2.1 Q's existence is restricted to its neural processes.

However, if Q functionally exists separately from all neural processes, why must it exist only with its neural process? For example, if Q is a visual quale, why must Q exist only with the visual perception neural process, a neural process in the occipital cortex? Why does Q not sometimes exist with this neural process but sometimes with other neural processes, such as neural processes in the basal ganglia, brainstem, and cerebellum? What is the mechanism that restricts Q's existence to its neural process?

PQ2.2 Q's existence with its neural processes is consistent.

However, if Q functionally exists separately from all neural processes, including its neural process, why must it exist consistently with its neural process? For example, if Q is an auditory quale, whenever the auditory perception neural process functions, why does Q consistently occur and exist with this neural process? Why does Q not exist inconsistently with this neural process (sometimes occurring but sometimes not occurring with this neural process)? What is the mechanism that keeps Q's existence with its neural process consistent?

PQ2.3 Q's manifestation is diverse and represents something.

Q's manifestation can be diverse in type by its nature. However, how can Q represent something? To represent something, it must have information about that thing to form the representation. For example, if Q is an image quale of a house or a sound quale of a song, as depicted in Figure 5.3, it must first have information about the house's image or the song's sound to form a representation of the house's image or the song's sound in the mind. However, if Q exists separately from all neural processes, where and how can it get the needed information? This poses a similar problem to that in problem 3 of PQ1.2.

PQ2.4 Q's manifestation matches its neural process's.

However, if Q functionally exists separately from all neural processes, it freely exists without functional restrictions from any neural process, so why do its manifestation details, ranges, and changes match those of its neural processes? For example, if Q is a visual or an auditory quale, why do its details (e.g., color, brightness, and shape of all points in the visual quale; or pitch, timbre, and loudness of all sounds in the auditory quale) match those of the visual or auditory perception neural process, respectively? Also,

why do its ranges (i.e., spectral, amplitude, and spatial) match those of the visual perception or auditory perception neural process, respectively? Further, if Q functionally exists separately from all neural processes, it freely exists without functional connections to any neural processes, including its neural process, so why must its changes match those of its neural process; why cannot it independently change?

In sum, what mechanism keeps Q's manifestation details, ranges, and changes matching those of its neural processes?

PQ2.5 Q's chronological aspects match its neural process's.

However, if Q functionally exists separately from all neural processes, it freely exists without functional restrictions from any neural process, so why do its chronological aspects (the time it occurs, represents things, and disappears) match those of its neural process? For example, when a foot hits a hard object, why does Q (a dull, aching pain quale representing this injury) not occur immediately after the hit but delayed for hundreds of milliseconds to a few seconds, which is the same amount of time its neural process takes to process the signal before signaling the pain to other parts of the brain? Why does Q not occur simultaneously with the hit and represent it in real time? Also, when we stop spinning around, we will continue to have Q (a quale representing the feeling of spinning) for a while. Only when the neural process stops creating this feeling does Q disappear. Why does Q not disappear at once when we become still? If Q functionally exists separately from all neural processes, why and how does it do so?

PQ2.6 Q's structure is definite.

However, if Q functionally exists separately from all neural processes, it freely exists without functional restrictions from any neural process, so why must its structure be definite? Why can freely existing visual qualia not have variable numbers and types of basic components and variable spectral characteristics among billions of people at different places and times? For example, why can visual qualia not have five basic components in some people, such as the reader, while having 1,2,3, or 6,7,8, or other numbers of basic components in others (i.e., the author, people around us, and all other people); and why can spectral characteristics of color qualia of the light spectrum, such as that in Figure 4.1, not vary between people—why cannot they be different between the reader, the author, and other people? What mechanism maintains the definiteness of their structures in all their free existence among billions of people, everywhere, and all the time?

PQ2.7 Q's structure is determined by its neural process.

However, if Q functionally exists separately from all neural processes, it freely exists without functional restrictions from any neural processes, including its neural process, so why must its structure be determined by its neural process?

PQ2.8 Q's interactions are via its neural process.

However, if Q functionally exists separately from all neural processes, it freely exists without functional restrictions from any neural processes, including its neural process, so why can it not interact with other qualia or mental processes directly? Why must its interactions occur via its neural process?

It is evident that Possibility I—a quale is an entity that functionally exists separately from all neural processes—raises several critical questions of how such an entity can have all the required physical properties of qualia, and several additional hypotheses are needed to support this possibility.

5.1.2 Possibility II: A quale is a functionally intrinsic entity.

If a quale is a functionally intrinsic entity in a neural process, what is it? Because this entity must fulfill the properties of qualia—most importantly, it must be consciously experienceable (because, indeed, the mind can be aware of and experience what the quale is like, and conscious awareness and experience of the quale do occur)—this entity must be a non-material entity that is readable by the consciousness neural process and can induce conscious awareness and experience of itself in the consciousness neural process.

First, let us find a neural process's intrinsic entity that is readable by the consciousness neural process. A neural process is the signal-processing process of its neural circuit. It intrinsically comprises many parts, such as signal reading, analysis, integration, internal transfer, and external transfer. Now, the only neural process's part readable by other neural processes, including the consciousness neural process, is the external transfer of signals, and the only part of the signals' external transfer readable by other neural processes is the signaling pattern. This is because neural processes communicate with each other through their signaling patterns. Therefore, signaling patterns fulfill the property of being a non-material entity readable by the consciousness process.

However, before we go on to check whether signaling patterns can induce conscious awareness and experiences of themselves in the consciousness neural process, let us be certain that we do not miss any other intrinsic entity that is readable by the consciousness process. In the literature, some theories propose that consciousness, a closely related phenomenon to qualia, arises from the brain's electromagnetic field (EMF) [30–33]. Because the brain's and neural processes' EMFs are non-material and functionally occur intrinsically in the neural processes, can a quale be its neural process's EMF? The answer is negative because, again, a quale must be readable by the consciousness neural process, but a neural process's EMF is not. This is because neural processes did not evolve to communicate via EMFs; they have evolved to communicate only via electrical/electrochemical signals at neural synapses. The synaptic electrical/electrochemical signals are determined almost exclusively by the propagating axonal [34–40] (or, in some far

fewer cases, dendritic [41–45]) action potentials, with probable minimal influence from something else, such as the surrounding EMFs, heat, and mechanical forces. Therefore, because neural processes do not communicate via EMFs, a neural process's EMF is not readable by the consciousness neural process and thus cannot be a quale.

Next, let us check whether signaling patterns can induce conscious awareness and experiences of themselves in the consciousness neural process. The fact is that, as noted above, we can be consciously aware of and experience qualia, which means that the consciousness neural process must be able to get information about qualia from something and be induced to form conscious awareness and experiences of them. Because the only things that the consciousness neural process can get information from are neural-process signaling patterns, as discussed in the preceding paragraph, *some signaling patterns must be able to provide the consciousness neural process with qualia's information* and induce conscious awareness and experiences of the qualia in it. However, the consciousness neural process receives numerous signaling patterns from various kinds of neural processes because its circuit, the consciousness neural circuit, is an extensive network with extensive connections.¹⁵ But when it processes the signals from these neural processes, it does not create conscious awareness and experiences for all of them. Hence, not all signaling patterns can induce conscious awareness and experiences of themselves, or awareness and experiences of what themselves are like, in the consciousness neural process—only some of them can. Those that can must be different from those that cannot—they must have certain special properties that enable them to induce conscious awareness and experiences of themselves in the consciousness neural process. One necessary property is that they must have information that means what themselves are like to the consciousness neural process so that, after the consciousness neural process reads them, it can use this information to form awareness and experiences of what they are like. Other probable special properties may be that the signaling patterns have special forms, are connected to the consciousness neural circuit via some special channels, or are connected to some special parts of the consciousness neural circuit. No matter what the special properties are, this theory assigns the term “*special signaling patterns*” to signaling patterns that can induce conscious awareness and experiences of themselves, or awareness and experiences of what themselves are like, in the consciousness neural process.

¹⁵ Current evidence suggests that the potential consciousness neural circuit or network is a) the Default Mode Network or Resting State Network [46–68], which is an extensive neural network for background consciousness and consciousness while resting; b) the network of Global Workspace theory proposed by Baars [69–75] or the network of the Global Neuronal Workspace hypothesis by Dehaene [76–83], both of which are extensive neural networks for access consciousness or consciousness of episodic stimuli that gain access into consciousness; or c) some combination of the networks in a) and b), such as the neural network in the extended theory of global workspace of consciousness proposed by Song [84]. See detailed discussions in Section 6.6.

Definition: A special signaling pattern (SSP) is a neural process's signaling pattern that can induce conscious awareness and a conscious experience of itself in the consciousness neural process.

Because a special signaling pattern (SSP) is non-material, is an intrinsically occurring entity in the neural process, is readable by the consciousness neural process, and can induce conscious awareness and experience of itself in the consciousness neural process, it can be the entity that a quale is. However, if qualia are SSPs of their neural processes, the SSPs must have all the physical properties of qualia; otherwise, qualia cannot be these SSPs. Do the SSPs have all the physical properties of qualia? This matter can be verified as follows:

PQ1.1 SSPs must be mental phenomena. That is, they must be non-material phenomena that coexist with the brain (see PQ1.1 in the previous chapter). Because SSPs are signaling patterns, they are information and thus non-material phenomena. Because they are signaling patterns of neural processes, they always coexist with the brain. Therefore, they are non-material phenomena and coexist with the brain—as required.

PQ1.2 SSPs must be consciously experienceable. Again, as summarized in Section PQ1.2 in the previous chapter, this means that each SSP must

1. be readable by the consciousness neural process,
2. be able to induce awareness and an experience of what itself is like in the consciousness neural process, and
3. be information about what itself is like.

We can verify these properties are as follows:

1. Because, by definition, an SSP is a signaling pattern that can induce conscious awareness and a conscious experience of itself in the consciousness neural process, an SSP is readable by the consciousness neural process—as required.
2. Because, by definition, an SSP is a signaling pattern that can induce conscious awareness and a conscious experience of itself in the consciousness neural process, an SSP can induce awareness and an experience of what itself is like in the consciousness neural process—as required.
3. Because an SSP can induce awareness and an experience of what itself is like in the consciousness neural process, it must be the information about what itself is like so that the consciousness neural process, after reading the SSP, can use this information to create awareness and an experience of what the SSP is like. Thus, an SSP is information about what itself is like—as required.

Therefore, with all the required properties satisfied, the SSPs are consciously experienceable—as required.

All additional physical properties of qualia can be verified as follows:

PQ2.1 Because SSPs occur only in the neural processes that produce SSPs, they do not and cannot occur randomly in the brain but occur restrictedly in the brain areas where these specific neural processes exist. Also, because only some specific neural process produces a certain SSP and no other neural processes produce this SSP, a certain SSP occurs with some specific neural process only. For example, the color-perception neural process produces an SSP that is the color-perception quale, and no other neural processes produce this SSP, so this SSP, the color-perception quale, occurs restrictedly with the color-perception neural process. All other qualia similarly occur restrictedly with their neural processes. Therefore, **SSPs' existence is restricted to their neural processes**—as required.

PQ2.2 Because SSP-producing neural processes always produce their SSPs whenever they function, SSPs consistently occur and exist with their neural processes whenever their neural processes function, and because these neural processes stop producing their SSPs whenever they stop functioning, SSPs consistently disappear whenever their neural processes cease functioning. Thus, **SSPs' existence with their neural processes is consistent**—as required.

PQ2.3 Because different types of neural processes that create different types of SSPs (for images, sounds, smells, emotions, thoughts, etc.) are in different brain areas (the occipital, temporal, olfactory, and frontal cortices, amygdala, etc.) and have different cytoarchitecture, myeloarchitecture, neural circuit connections, neurotransmitters, neurotransmitter receptors, and functions [85–102], these different types of neural processes are anatomically, structurally, and functionally different from each other. Therefore, each type creates a signaling pattern of its type, which is unique and different from those of other types. While major differences in patterns of SSPs are responsible for different types of manifestations (images, sounds, smells, emotions, thoughts, etc.), minor differences in patterns create different details in the same type (different images, different sounds, different emotions, etc.). With the estimated 100 to 1,000 trillion synapses in the brain [97,103–105] and with various kinds of encoded signals, such as population, rate, temporal, and mixed encoded signals [106–128], passing through this multitude of synapses, even a portion of the entire neural circuits of the brain can create virtually infinite numbers of unique SSPs that can represent practically anything, including all images, sounds, feelings, thoughts, and memories we experience throughout our lives. Regarding the mechanism for SSPs to represent things in the outside world, they can do so because their neural processes can get information about those things via various sensors and perception systems of the nervous system and later incorporate those things' information into their signaling patterns. Hence, **SSPs' manifestations are diverse in type and detail and can represent various things**—as required.

PQ2.4 Because SSPs are signaling patterns of their neural processes and neural processes display their manifestations (i.e., present their information to other neural processes) via their signaling patterns, *SSPs' and neural processes' manifestation ranges and details are naturally the same*. Also, because signaling patterns are intrinsic parts of neural processes, it is inevitable that *SSPs' manifestations change similarly to and concurrently with those of their neural processes*.

Thus, **SSPs' manifestations match their neural processes'**—as required.

PQ2.5 Because neural processes display their manifestations (i.e., present their information) to other neural processes via their SSPs, neural processes' and SSPs' chronological aspects regarding their manifestations are the same. That is, the time neural processes' and SSPs' manifestations occur, represent things, and disappear are the same.

Notably, after a quale-producing neural process receives signals about something, it takes some time to process them before creating an SSP to represent that thing. Hence, the resulting SSP does not occur immediately when the body receives signals of that thing and thus does not represent that thing in real time but in a time-lag manner. The lagging time equals the time its neural process takes to process the signals and then produce the SSPs. Thus, the lagging time of an SSP is naturally the same as that of its neural process. Also, regarding disappearances, even though signals from a stimulus stop entering the body, such as when one closes the eyes after looking at a lamp or stops spinning one's body after whirling for a while, the related neural process continues functioning and producing its SSP for some time. Hence, the SSP keeps occurring and representing that thing or event that no longer exists until its neural process ends producing it.

Accordingly, **SSPs' chronological aspects match their neural processes'**—as required.

PQ2.6 Because *the number and types of basic-component SSPs* of any type of quale are determined by the number and types of basic-component neural processes of that quale type and because *the number and types of such neural processes* are fixed and definite (such as the number of basic-component neural processes of vision is always five, and the types of basic-component neural processes of vision are always color, brightness, shape, dimension, and movement) for all humans, *the number and types of basic component SSPs of any type of quale are fixed and definite* (not different among people).

Also, because *the spectral characteristics of SSPs* of any type of quale are determined by the neural processes of that type of quale (such as the spectral characteristics of SSPs of the color quale are determined by the color perception neural process that produces the SSPs) and because *the functions of those neural processes are definite* (not different among people), *the spectral characteristics of SSPs of any type of quale are definite* (not different among people).

Thus, **SSPs' structures are definite**—as required.

PQ2.7 Because the number and types of basic component SSPs and the spectral characteristics of SSPs of any type of quale are determined by their neural processes, **the structures of SSPs are definite and determined by their neural processes**—as required.

PQ2.8 Because SSPs are signaling patterns of neural processes and interactions of neural processes' signaling patterns occur via their neural processes' synapses, **the SSPs' interactions are via their neural processes**—as required.

Therefore, SSPs have all the required physical properties of qualia. Also, because what qualia can function to do or be depends on their physical properties and because SSPs have the physical properties of qualia, it can be deduced that SSPs can function to do or be as the qualia can. Thus, SSPs can have functional properties of qualia, such as being ineffable, intrinsic, and private [13,24,25,129–133], being irreducible [133], being directly or immediately apprehensible in consciousness [130], being irrevocable, having output flexibility, enduring in short-term memory [134], and having enormous multi-variability and combinatorial capacities [135]. For example, any signaling pattern is intrinsic and private because a certain signaling pattern occurs only in the individual who is having it. Also, all signaling patterns are ineffable because there is no sensory apparatus or neural circuit built to get information about what the signaling patterns are [19,136]. Neural circuits have evolved to get only information that signaling patterns contain, which is information about something else they are representing, not about what the signaling patterns themselves are. Thus, there is no information to describe them other than the “what things that they are representing are like” that the consciousness neural process receives from them.

5.2 Theorem IV

In summary, there are two possibilities: I) A quale is a functionally separate entity from all neural processes and II) A quale is a functionally intrinsic entity in a certain neural process—specifically, a quale is the SSP of a neural process. The first possibility has to devise an unknown entity and needs several additional hypotheses to explain how this unknown entity can have the “must-have” physical properties of a quale. In contrast, the second possibility does not have to invent any new entity—an SSP is an inherent entity in a neural process—and it has all the required physical properties of a quale without having to formulate additional hypotheses to explain them. Therefore, based on parsimony, it is rational to choose the second possibility and conclude that a quale is an SSP. This theory asserts this conclusion as Theorem IV.

Theorem IV: A quale is a special signaling pattern (SSP).

This is the specific form of Theorem IV. However, because an SSP is a special signaling pattern—a signaling pattern in some special form—a quale is simply a special kind of signaling pattern. Furthermore, as a special kind of signaling pattern is basically a signaling pattern, a quale is fundamentally a signaling pattern. Thus, the more basic form and the most basic form of this theorem can be stated as:

Theorem IV: A quale is a special kind of signaling pattern.

Theorem IV: A quale is a signaling pattern.

Now, to avoid losing sight of what this means, let us expand the term quale according to its definition. We will see that this theorem means that *a non-material phenomenon that is consciously experienceable (able to induce awareness and an experience of what itself is like in the mind) is a special kind of signaling pattern*, or most basically, *is a signaling pattern*. In plain language, this means that an image of a house, a sound of a song, an odor of a flower, a feeling of happiness, a thought of one's self, etc. in our minds are simply signaling patterns in our brains.

Because a neural process's signaling pattern is the neural process's information that is sent to another neural process, a quale or an SSP is a special kind of neural process's information that is sent to another neural process. This special kind of information means a quale or a phenomenon manifesting what itself is like to any receiving neural process that can interpret it correctly. The consciousness neural process is one such a receiver. Thus, to the consciousness neural process, an SSP and its information mean a quale. Therefore, after the consciousness neural process reads and processes the SSP, it will interpret the SSP as such, and a quale will appear in its process. Furthermore, with its specialized ability, it can use this information to create conscious awareness and experience of the quale. This is how a phenomenal quale (or a phenomenon that manifests what itself is like in the mind) and conscious awareness and a conscious experience of the quale occur in the brain. For example, an SSP that is a visual quale of a house is the information that means the visual quale of a house (or the mental house image that manifests what itself is like) to the consciousness neural process. Hence, when the consciousness neural process reads the SSP, it will interpret the SSP as such, and the visual quale of the house will naturally and inevitably occur in the consciousness neural process and thereby in the brain. Further, with its specialized ability, it will create conscious awareness and experience of the visual quale from this information. Consequently, conscious awareness and experience of the visual quale of the house will and must occur in it and the brain.

In principle, for signaling patterns to be qualia or phenomena that manifest what themselves are like in the mind, they must have the correct information—again, the information that means qualia, phenomena that manifest what themselves are like, to

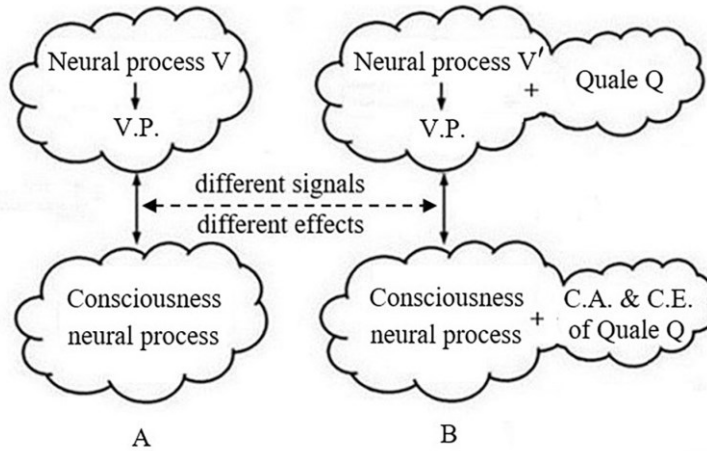
some neural process. But how is it possible that signaling patterns can have such information? The answer is that it is a brute fact. In this universe, it is basically possible for some physical patterns to have such information. During its evolution, the nervous system has evolved countless kinds of signaling patterns with uncountable information meanings for neural processes to perform various functions. SSPs are just evolved signaling patterns with a new kind of information, qualia, for a new kind of neural process, the consciousness neural process, to perform a new function: a new kind of awareness and experience—conscious awareness and conscious experience. This interesting and important matter will be revisited and discussed in detail in Chapter 8: The Explanatory Gap.

Therefore, physically and ontologically, a quale is neither a novel physical nor a new non-physical entity but just an under-recognized part of a well-recognized physical entity. It is the signaling pattern of a neural process—the inherent, informational part of a physical process. Because a signaling pattern is inherent in a neural process, nothing in the brain emerges to be qualia. It seems as if something emerged to be qualia only because special signaling patterns have new information—the information that means “phenomena that manifest what themselves are like” or qualia—while other signaling patterns do not. Yet they also have their own information; it is only that their information means something else. To repeat this very important point, signaling patterns and information are inherent in neural processes; only the evolution of their meanings into new meanings makes it look as if something (qualia) emerged. However, regarding signaling patterns, information, meanings, and functions, it can be said that new signaling patterns with new information, new meanings, and new functions *evolved*, not *emerged*, from old signaling patterns with old information, old meanings, and old functions, with no novel entities emerging in the process. This kind of evolution is not exceptional. New signaling patterns with new information, meanings, and functions have constantly been evolving during evolution. This has always been true and, according to all the evidence we have, will always be.

5.3 Physical Effects of Qualia

Do qualia have physical effects, or are they epiphenomena without any physical effects? The answer is that qualia have physical effects. This is the case because they are signaling patterns, so they can convey information to other neural processes and hence affect them. This matter can be investigated in more detail as follows:

Consider Neural Process V (Figure 5.4A), which functions to produce visual perception (V.P.) of a house without a quale occurring. Compare it with Neural Process V' (Figure 5.4B), which functions to produce visual perception (V.P.) of the same house but with a visual quale of the house, Quale Q, occurring.



V.P. = visual perception, *C.A.* = conscious awareness, *C.E.* = conscious experience

Figure 5.4 Effects of a quale

It is obvious that there are differences between the signaling pattern of Neural Process V and that of Neural Process V'. Neural Process V produces visual perception of a house without a visual quale of the house, so its signaling pattern has information only about the visual perception of the house. On the other hand, Neural Process V' produces both visual perception of a house and a visual quale of the house, so its signaling pattern has information about both the visual perception of the house and the visual quale of the house. Hence, the signaling patterns of the two neural processes must be different because they are information about different things. When these signaling patterns are sent to and then read by other neural processes, different physical effects will occur in those neural processes, at least because of the processing of different signaling patterns.

One evident and important differential effect is that there is no conscious awareness or conscious experience of any quale occurring in the consciousness neural process in the former case because there is no quale for them to occur (as in Figure 5.4A), whereas there are conscious awareness and experience of a quale (Quale Q) occurring in the consciousness neural process in the latter case because there is a quale for the consciousness neural process to process and then create conscious awareness and experience of that quale (as in Figure 5.4B). Because conscious awareness and experience must occur from some mental processes, which in turn must occur with some neural processes (Theorem I), a quale induces additional neural processes. As neural processes are physical, a quale induces physical processes and thus has physical effects.

Moreover, the physical impact of each signaling pattern on its own neural process is different because different signaling patterns entail different production, operation, and

maintenance, which require different physical resources. Thus, apart from the effects of the quale on other neural processes, having a quale in a neural process also physically affects that neural process. Therefore, a system that has qualia is physically different from a system that does not.

At present, it still cannot be definitively concluded from existing research and studies what the exact physical effects of qualia are. As qualia occur only in the final stages of sensory perception and some of the highest-level emotion, cognition, and execution mental processes, it is probable that qualia evolved to augment functions of these important mental processes, such as to augment effects of sensory-perception or emotion-generation mental processes so that they have stronger effects on other mental processes, such as thought or autonomic system mental processes [18,19,134]. Evidently, these effects must yield some benefits for the animals that possess qualia, such as (definitely) humans and (probably) other high-level animals that have similar brain structures capable of supporting qualia occurrences (e.g., other mammals, birds, and reptiles) [137,138]), because they seem to be thriving.

5.4 Predictions

According to Theorem III, a quale will be found to occur with a certain neural process, and this neural process can be found as described in Prediction 2 in Section 4.3. In the predictions below, this neural process will be referred to as its (the quale's) neural process.

1. Every quale will be found to be the signaling pattern of its neural process. For example, a visual quale and an auditory quale will be found to be the signaling patterns of the visual and the auditory perception neural processes, respectively.
2. It will be found that a) the signaling patterns that are qualia have categorically different characteristics from those that are not—that is, qualia are a special kind of signaling pattern (special signaling pattern or SSP)—and b) signaling patterns of different kinds of qualia (visual, auditory, olfactory, etc.) are significantly different from each other but do have some basic characteristics in common.
3. A quale can be identified, quantified, or monitored by identifying, quantifying, or monitoring, respectively, only the SSP of its neural process. These SSP investigations are both necessary and sufficient for the corresponding quale investigations to result, while these actions on anything else without involving the SSP will not result in the corresponding quale investigations.
4. A quale can be created, modified, tested, or destroyed by creating, modifying, testing, or destroying, respectively, only the SSP of its neural process. These actions on the SSP are both necessary and sufficient for the corresponding actions

on the quale to occur, while these actions on anything else without involving the SSP will not result in the corresponding actions on the quale.

5. In an event or experiment, all predictions that are valid for the SSP of the quale's neural process, such as whether the SSP will occur, change, or disappear, will be identically valid for the quale. For example, if it is predicted that the SSP will change its pattern abruptly from being the signaling pattern of a static, faint, homogenous red to being the signaling pattern of a dynamic, vivid, complex movie, it will be found that the changes in the quale will be identical in all aspects, such as identical changes from a homogeneous color to a complex movie (quality), from faint to vivid (quantity), and abruptly from static to dynamic (temporal pattern).

All the above predictions can be verified by experiments in conscious, communicative human subjects. A typical experiment is to monitor a quale's occurrence, existence, change, etc. by having the subject report what happens to the quale in his or her mind while concomitantly monitoring the signaling pattern of its neural process by methods such as MEG, ECoG, and intracortical recordings and while the signaling pattern is being manipulated by methods such as drug administration, transcranial magnetic stimulation, or transcranial electrical stimulation.

5.5 Remarks

It should be noted that the ideas that the signaling pattern of a neural process is a quale and that no new entity emerges from the neural process to be a quale are not novel. They have been proposed by several authors before, such as *Clark (1995)* [129], *Llinás (2002)* [139], *Sevush (2006)* [140], *Orpwood (2007, 2010, 2013, 2017)* [5–8], *Loorits (2014)* [3], *Fazekas and Overgaard (2017)* [141], and others [142–147]. Specifically, for example, *Clark (1995)* said that “*subjective qualitative experience is identical to certain information-bearing, behavior-controlling functions, not something which emerges from them.*” [129]. This theory just proves explicitly and specifically that it is the special signaling pattern, the signaling pattern in some special form, that is a quale. Similarly, it should be observed that the concept that some kind of neural information is a quale is not new either. This has already been proposed before by some authors, such as *Orpwood (2007, 2010, 2013, 2017)* [5–8], *Balduzzi and Tononi (2009)* [1], and *Haun et al. (2017)* [147]. Specifically, *Orpwood* asserted that qualia are information cycled through a hierarchy of networks in a resonant state. He proposed that the input information about what X is, when repeatedly cycled through a hierarchy of networks in a resonant state, will finally evolve into information about how X seems to the network and that this information about how X seems to the network is a quale. *Balduzzi and Tononi* theorized in the Integrated Information Theory (IIT) that qualia are a geometry of integrated

information. They proposed that the quantity of consciousness is the amount of integrated information generated by a complex of elements and that the quality of experience (a quale) is specified by the informational relationships it generates, meaning that a quale is the geometry of the integrated information.

On the other hand, this theorem (Theorem V) does not contend that information must be repeatedly cycled through neural circuits to be a quale as Orpwood does. It is possible that information can become a quale in one pass through a quale-generating neural circuit if the neural circuit has a correct structural and operational configuration, like a special-purpose electronic chip that can execute a specific task, such as a calculation of a transcendental function, in one pass instead of multiple passes through simple logic circuits in a general-purpose chip with the help of some software. However, the characteristics of the structure and processing processes of the neural circuit that can create a quale in one pass are presently unknown, so this is just a theoretical possibility. Also, unlike the IIT, this theorem does not hold that qualia are the geometry of integrated information but asserts that qualia are information themselves. Based on this theorem, information can be a quale if and only if it means “quale” or “mental phenomenon that manifests what itself is like” to the consciousness neural process. Thus, according to this theorem, the meaning, not the complexity or geometry, of the information is the determining factor of whether any information is or can be a quale. Lastly, because this theorem asserts that a quale is a signaling pattern that a neural process sends to the consciousness neural process and because signaling patterns that neural processes send to others become effective only at neural synapses, ultimately, qualia are likely to be the patterns of synaptic electrical activities, not neuronal dendritic activities as *Sevush (2006)* [140] proposed.

*If we open our eyes and experience visual qualia
occurring right in front of us now,

with the fact that we can experience qualia
only if the brain can experience the qualia,

it is inescapable to conclude that we are, in fact,
experiencing neural signaling patterns,

because the only things the brain can experience
... read and process ...
are neural signaling patterns.*

Chapter 6

Consciousness

Consciousness is one of the most important mental phenomena of the mind. It can rightly be considered the supreme mental phenomenon because it makes us sentient in a special way that differentiates us from present-day artificial intelligence (AI). Without it, no matter how intelligent we are, we will be just robots of some kind, roaming this planet without having awareness and experiences of what it is like to be ourselves, to see colorful flowers, to hear melodious music, to feel tender touch, to feel happiness, and so on in our minds.

However, consciousness is a term that has various meanings [1–21], and the meaning used above is just one of them. This theory investigates consciousness only in this meaning to answer questions about it. First, this chapter clarifies what consciousness in this meaning is and how it relates to consciousness in other meanings. The next chapter resolves the questions of its nature: what it is physically and ontologically, why and how it occurs, and other related questions.

6.1 Consciousness: Definition

If our mind is examined while we are not engaged in any specific activity, it will be found to have many mental processes going on concurrently as resting-state mental processes—for example, thinking casually, experiencing a light mood, and perceiving trivial sensations (such as non-exciting visions, soft sounds, and light touches) from the uneventful surroundings. When there is a strong enough stimulus, either external (a flash of light, a loud call, a needle prick, etc.) or internal (a popping-up thought of an urgent task, a sudden reliving of a past exciting incident, a pang of sorrow, etc.), our attention will be directed to that stimulus, and our concentration will focus on it. In addition, the mind will become less aware or even unaware of the resting-state mental processes that are unrelated to the stimulus. For example, when exciting news appears on television and we turn to watch it, we may become less aware or unaware of the sounds in the surroundings, not register pain in our backs, and not feel any emotion that we felt before. Thus, normally, when we are awake, many mental processes occur in a dynamic state—some become dominant for some time, and some become marginal or even disappear for some time. However, whether we are doing nothing or concentrating on something, some mental processes are always at work if we are awake and in a normal condition. One of them functions to be aware of and experience mental phenomena (such as image, sound, and emotion) with awareness and experiences of what those mental phenomena are like

(such as what the image of flowers is like, what the sound of music is like, and what the feeling of happiness is like) occurring.

Because this mental process functions to be aware of and experience mental phenomena with awareness and experiences of what the mental phenomena are like occurring, this mental process functions to be consciously aware of and consciously experience mental phenomena (see Section 3.1), and the awareness and experiences of what those mental phenomena are like that occur are called conscious awareness and conscious experiences, respectively (see Section 3.4). Accordingly, in this theory, this mental process will be called *the consciousness mental process* and can be defined as:

Definition: The consciousness mental process is the mental process that functions to be consciously aware of and consciously experience mental phenomena.

Equivalently, it can also be defined as:

Definition: The consciousness mental process is the mental process that functions to create conscious awareness and conscious experiences.

However, under normal conditions, the mind is consciously aware of and consciously experiences several mental phenomena (such as images, sounds, touch, emotions, and thoughts) simultaneously. Hence, under normal conditions, several kinds of conscious awareness and conscious experiences occur concurrently. Therefore, under normal conditions, the consciousness mental process functions to create a composite of all conscious awareness and conscious experiences. If we define consciousness as what the consciousness mental process functions to create, then consciousness is the composite of all conscious awareness and conscious experiences. This is its definition in this theory:

Definition: Consciousness is the composite of all conscious awareness and conscious experiences.

According to the definitions and discussions of conscious awareness and conscious experiences in Section 3.4, the above definition means in detail that *consciousness is the composite of all awareness and experiences of what qualia are like*. Equivalently, it means that *consciousness is the composite of awareness and experiences of what all occurring qualia are like*. In real life, this means that consciousness is the composite of awareness and experiences of, among other things, what an image of a house, a sound of a song, an odor of a flower, a feeling of happiness, and a thought of one's self are like. Since qualia are representations of things in our lives (see Section 3.7), in plain language, *consciousness is the composite of awareness and experiences of what the things in the outside world are like in their various representations (image, sound, smell, taste, touch, etc.)*. In this theory, when conciseness is required, this last description will be shortened to "*consciousness is awareness and experiences of what things are like.*"

Also, because the composite that is consciousness comprises only conscious awareness and conscious experiences, to be concise, the shorter terms—*the composite*, *conscious awareness and conscious experiences*, and *conscious awareness and experiences*—will be used (instead of the full, longer term: the composite of ...) interchangeably to mean consciousness in general discussions about it. Which term will be used depends on the aspect being focused on at that point. Also, when we investigate consciousness in a specific situation, such as perception of an image, sound, or smell individually, the term *consciousness of* or (be) *conscious of*, such as consciousness of a red color quale, consciousness of a musical sound quale, or (be) conscious of a flower smell quale, will be used instead of the base terms *consciousness* and *conscious* to denote this specificity. *Consciousness of* in this usage is just conscious awareness and a conscious experience of that quale; it is not consciousness in general, which is the composite of all conscious awareness and conscious experiences.

Finally, it is important to note that consciousness by this definition involves phenomenality or manifestation of what itself is like in the mind in two aspects:

I. Because awareness and experiences of what qualia are like (what an image of a house, a sound of a song, an odor of a flower, etc. are like) occur when we are conscious of those qualia, it means that awareness and experiences of the *phenomenality* of those qualia occur when we are conscious of them.

II. Because we can be consciously aware of and consciously experience what our consciousness is like, our consciousness itself is consciously experienceable and manifests what itself is like in the mind; thus, consciousness itself is a quale and has *phenomenality*.

Sometimes, to emphasize the involvement of phenomenality, the term *phenomenal consciousness* [2,4,8–10,12,15–18,22–37] will be used, but it means the same as consciousness.

6.2 Other Definitions of Consciousness

The definition of consciousness in the previous section is just one definition among several others. Consciousness is an artificial concept. The mind comprises numerous interrelated mental processes and has various aspects. It is arbitrary for anyone to choose, according to his or her opinion, which aspect to focus on and which one or ones of those mental processes should be called or grouped together to be called “consciousness” [7]. This results in the term “consciousness” having varied meanings and referring to related but not the same entities. Hence, to avoid confusion in the following discussions, which involve consciousness of varied definitions, consciousness (regular typeface) is used in this chapter to represent a term that is used generally and can have varied meanings, whereas *consciousness* (bold and italics) is used to denote a term that has a fixed meaning as defined in the previous section. Their adjective forms are conscious and

conscious, respectively. In other chapters, only consciousness (regular typeface) is used to avoid difficulties in reading; most of the time, it refers to consciousness as defined by this theory, but sometimes, consciousness in other meanings, depending on the context.

Some of the most common meanings of the terms consciousness and conscious are as follows:

1. *A creature's state of being awake, responsive, and capable of performing mental functions.* For example, he lost consciousness in a car accident and was unresponsive afterward, with no eye opening, vocalization, or motor response to any stimuli; however, a few hours later, his consciousness returned to normal—he became awake, responsive, and capable of performing mental functions normally, with eye opening, vocalization, and motor responses to stimuli, as usual.

Compared with *consciousness*, consciousness in this meaning is different because it does not require that awareness and an experience of what something that one is conscious of is like must occur; just being awake, responsive, and capable of performing mental functions is enough for consciousness to occur. Therefore, any animal that is awake, responsive, and able to perform mental functions can rightfully be said to be conscious and have consciousness in this meaning. Similarly, because functioning robots are manifestation-wise awake, responsive, and capable of performing electronic functions comparable to human mental functions, such as sensing stimuli, processing information, and commanding their effectors (e.g., sound-producing devices, arms, or legs), resulting in human-like behaviors, such as sensing things (see, hear, smell, etc.), assessing situations, making decisions, remembering things, and performing human-like activities (move around, talk, work, etc.), one can argue that, at least manifestation-wise, robots are conscious and have consciousness in this meaning.

2. *A mental state of being aware of something.* In this meaning, consciousness is typically used in its adjective form, conscious. For example, he is conscious of the smell in the room; she is conscious of the pain in her body; and we are conscious of what is going on around us.

Compared with *conscious* and *consciousness*, conscious and consciousness in this meaning are different because they do not require that awareness and an experience of what something that one is conscious of (such as the smell or pain) is like must occur; just being aware of something is enough to be conscious and for consciousness to occur. Therefore, one can argue that animals and robots are also conscious of things and have consciousness in this meaning because they are aware of things around them, such as images, sounds, smells, and other things, and can react to them accordingly.

3. *A mental state of being aware of something with attention, resulting in detailed information about that thing gaining access into the brain's workspace*, where it is distributed to various parts of the brain (or becomes globally available) to be processed by other processes (such as analyzing, memorizing, and reporting processes). Because, in this case, consciousness occurs when something's information gains access into the brain's workspace, many authors call this type of consciousness "access consciousness" or "a-consciousness" [4,8,10,12, 16,18,22–25,32,38–43]. For example, when a man was walking through a crowd in a mall, his attention was caught by a loud announcement; he became conscious of the message that there would be a show at the convention hall on the third floor at 4 pm; after thinking for a while, he decided to attend, remembered the place and time, and called his friends to tell them about it. This means that the detailed information about the message had gained access to his brain's workspace and was distributed globally to other processing processes with the occurrences of, in addition to access consciousness of the message, several other activities, including analyzing, decision-making, memorizing, and reporting. This contrasts with the sounds of the crowd and other things in the mall that may have entered his mind in another way: without attention and detailed information. Although he was aware of them, as evidenced by the fact that he was able to tell that there were sounds in the surroundings other than the sound of the announcement, his consciousness of these background sounds lacked the important characteristics mentioned above—further processing of the details of those sounds (such as analyzing, memorizing, and reporting) did not occur (because the detailed information did not enter the brain's workspace and, thus, was not distributed globally for wider processing). In this case, some kind of consciousness of the surrounding sounds (such as consciousness in the second or fifth meaning) must have occurred, but it was not access consciousness like the one that occurred for the announced message.

Compared with *consciousness*, consciousness in this meaning or access consciousness is different because it does not require that awareness and an experience of what something that one is conscious of (such as the announcement sound) is like must occur; just being aware of something with attention with the result that its detailed information becomes globally available and can be processed in various ways, as mentioned above, is sufficient for consciousness or access consciousness to occur. Therefore, when used in this meaning, one can argue that animals and robots also have consciousness or access consciousness because they can be aware of things with attention so that detailed information about those things becomes globally available in their minds or processing systems (in the case of robots)—this is evident from their behaviors, which

reflect acquisition, integration, and utilization of the available detailed information.

4. ***A composite of mental processes that performs complex functions, resulting in complex abilities and behaviors.*** These complex functions are numerous, such as binding several components of sensory inputs (such as shape, color, and brightness components of a visual input) into a single unified percept (such as a complete image), selecting a certain stimulus from various stimuli to process, directing attention to and maintaining concentration on the selected stimulus, creating and modulating emotions, recognizing oneself and others' selves, remembering things, searching past memories, utilizing past experiences, analyzing situations, comparing choices, making decisions, planning actions, executing flexible, goal-directed behaviors, and creating and using tools [1,2,18,44–49]. For example, healthy people are conscious in this meaning because they can perform the complex mental functions just mentioned, as is evident from their complex behaviors, which require complex mental functions.

Compared with *consciousness*, consciousness in this meaning is different because it does not require that awareness and an experience of what something that one is conscious of is like must occur; just being able to perform complex mental functions resulting in complex abilities and behaviors is enough for consciousness to occur. Therefore, when used in this meaning, one can argue that several types of animals, such as insects, fish, reptiles, birds, and mammals, have consciousness because they exhibit complex abilities and behaviors that require complex mental functions. Many people consider these complex mental functions as markers of consciousness in animals or even as animal consciousness itself [43,44,50–53]. Similarly, one can argue that robots also have consciousness in this meaning because functioning robots have electronic processing functions that are equivalent to these complex mental functions, resulting in similar complex abilities and behaviors. For example, they can perceive complex stimuli, remember and recall things, analyze situations, make decisions, plan actions, command their effectors to work, and play complex games (such as chess, Go, and bridges) [54–58].

5. ***A mental state of being aware of and experiencing something with awareness and an experience of what that thing is like occurring.*** For example, when we look at a red color and a red color quale occurs in our minds, awareness and an experience of what the red color quale is like occur; that is, consciousness of the red color quale occurs. Because awareness and an experience of what the red color quale is like—which are awareness and an experience of the red color quale's phenomenality—occur, many authors call this kind of consciousness “phenomenal consciousness” or “p-consciousness” [2,4,8–10,12,15–18,22–37].

Compared with *consciousness*, consciousness in this meaning is similar because it requires that awareness and an experience of *what something that one is conscious of* is like must occur. In this meaning, we cannot be certain or argue with strong evidence that animals have phenomenal consciousness because they cannot report to us whether they are aware of and experience *what something that they are conscious of* is like in their minds. Also, it is certain that present-day robots do not have phenomenal consciousness because they are definitely unaware of and do not experience *what something that they are aware of* is like in their processing systems. This is because, in a robot, every function requires a specific circuit or software—no function in a robot is possible without a specific circuit or software. But a present-day robot simply does not have a specific circuit or software for it to be aware of and experience what something is like (because we, its creators, do not build such circuits and software for it as we, at present, plainly do not know how to do so). Therefore, it is clear that current robots do not have phenomenal consciousness (a more detailed discussion on this matter is provided in Chapter 9, Section 9.3.1: Do computers and robots have qualia and consciousness?).

People usually use the terms conscious and consciousness in the first, second, or fourth meanings. The terms in the third meaning are mostly used by neuroscientists. Several neurological theories of consciousness, such as the Global Workspace Theory [59–64], Global Neuronal Workspace Hypothesis [65–70], and extended theory of the global workspace of consciousness [71], are about consciousness in this meaning. Animal cognition and robotics scientists usually use consciousness in the fourth meaning. Most philosophers, as well as some neuroscientists, discuss the terms in the fifth meaning; the hard problem [1–3,8,16,17,26,29,36,37,72–78] and explanatory gap of consciousness [1–3,8,15,16,25,27,29,35–38,73,79–83] are the problems about consciousness in this meaning. Consciousness investigated in this theory, *consciousness*, is also consciousness in this fifth meaning.

It should be noted that these types of consciousness are not mutually exclusive. In fact, they usually occur together. For example, the consciousness that occurs when one attends to a stimulus (such as the announcement sound in the example above) is consciousness in all the five meanings: consciousness in the first meaning because one is awake, responsive, and capable of attending the announcement; in the second meaning because one is conscious of the announcement; in the third meaning (or a-consciousness) because one pays attention to the announcement with the result that its detailed information gains access into the mind and becomes globally available for various processing processes; in the fourth meaning because one is able to perceive and interpret the announcement (which requires complex mental functions); and in the fifth meaning (or p-consciousness) because one can be aware of and experience what the quale of the announcement sound is

like. However, sometimes, the consciousness that occurs can be consciousness in only some but not all meanings. For example, in the example of the man in the mall, consciousness of the background sounds can be considered consciousness in all but the third meaning, as discussed previously.

6.3 Other Meanings and Related Terms

There are still other but less common usages of the word consciousness in other meanings. For example, some use the term consciousness interchangeably with the mind [12,13,84] or all mental processes that function to evaluate and model the world [85] or with a non-material entity that pervades the universe, the term used in some beliefs and religions [18,85–89]—all of these probably have too broad meanings. Some use consciousness to mean thought or self-consciousness, which is obviously too narrow a meaning [4,15–18,20,36]. Also, some use consciousness to mean knowledge—that is, “one is conscious of something” means “one has knowledge of it”; this meaning is certainly too narrow as well [4,17,18,36]. Moreover, things are even more complicated because other words are sometimes used to refer to consciousness, such as awareness, feelings, the first-person perspective, phenomenality, phenomenal experience, qualia, and subjective experience [74,90]. Therefore, the reader should be careful about the meanings of the terms consciousness, conscious, and other mentioned wordings when finding them in literature.

Regarding the content of consciousness, because consciousness in some usages (such as that in the first and fourth meanings) does not require that, to be conscious or have consciousness, one must manifestly be conscious of something, some authors use the word “intransitive consciousness” [16,24,45,91] to describe such consciousness. On the other hand, the word “transitive consciousness” [12,16,24,45,91–93] is used to describe consciousness that overtly has content (such as that in the second, third, and fifth meanings), in which case one can be said to be conscious of something. In addition, some authors consider consciousness to be “state consciousness” or “mental-state consciousness” if the consciousness is just a state of the mind (such as that in the second, third, and fifth meanings) but “creature consciousness” if the consciousness is a property of the whole creature (such as that in the first and fourth meanings) [12,16,24,45,91,92].

Finally, many specific terms are used by different authors for different types of consciousness that have different types of awareness content. The most basic consciousness, which has awareness only of sensory perception, is usually called “primary consciousness” [27–29,94–100], “core consciousness” [101,102], “sensory consciousness” [28,51], “perceptual consciousness” [94,96], or “anoetic consciousness” [100,103]. A more complex consciousness that has awareness of not only sensory perception but also other things is called “higher-order consciousness” or “higher-level

consciousness” [94,95,99]. More specifically, in addition to awareness of sensory perception, a higher-order consciousness that has awareness of executive control, decision making, voluntary action, one’s own thoughts, and one’s own awareness is called “noetic or reflective consciousness” [94–96,100,103], and a higher-order consciousness that also has awareness of one’s own identity over time is called “autonoetic consciousness” [100,103]. It should be noted that the definitions of these terms do not specify phenomenality as a part of consciousness. Thus, even with the current technology, we can make computers or robots aware of the content of these types, and one can argue that such computers or robots have consciousness as defined in these terms. On the contrary, this theory requires phenomenality to be part of *consciousness* but does not specify the kind of its content. The *consciousness*’s content can be simple awareness of sensory perception or complex awareness of executive control, decision making, voluntary actions, etc. The determining point is that, if phenomenality occurs, it is *consciousness*; if not, no matter how complex its content is, it is not *consciousness*.

In summary, the meaning of *consciousness* is similar to consciousness in the fifth meaning. To reiterate, *consciousness* is the composite of all conscious awareness and conscious experiences—the composite of all awareness and experiences of what qualia are like. This theory deals with consciousness in this meaning because only in this meaning is consciousness *phenomenal consciousness*, which differentiates sentient from non-sentient beings and separates us from AI, as noted previously. Without having the awareness and experiences of what qualia are like, even the most highly intelligent and capable brains will function and be just like central processing units in present-day computers and robots. For other authors, the opinions may be that consciousness should also include complex mental functions [18,45–49], such as those exemplified in the fourth meaning of consciousness. However, those functions can be set up even in today’s computers, robots, and other types of AI, and AI can be even better (faster, more accurate, more stable, less exhaustible, more knowledgeable, etc.) at those functions than we are. On the other hand, AI cannot be aware of and experience what qualia are like, while, contrastingly, we can. Thus, those functions do not distinguish us from AI, but awareness and experiences of what qualia are like do. In addition, opinions may vary on how many of those functions and which ones of them should be included in the entity that one wants to call consciousness. Therefore, because the term *consciousness*, as defined in Section 6.1, differentiates us from AI and suffices for discussions on the most important problems of consciousness, such as the hard problem and explanatory gap, it is adequate and will be used as the working definition in this theory. This definition can be considered the minimum definition of consciousness; a wider definition that includes some complex mental functions is possible but is not needed in this theory. It will be seen that any wider definition will not affect the conclusions and predictions of theorems in this theory, which uses this minimum definition.

6.4 Other Aspects of Consciousness

There are some other aspects of consciousness that should be discussed to understand consciousness more comprehensively. They are as follows:

I. It should be noted that the consciousness mental process does not function to be consciously aware of and consciously experience all mental phenomena (or products of mental processes). Therefore, conscious awareness and experiences, and thus consciousness, do not occur for all mental phenomena, as discussed in Sections 3.4 and 3.5. Some mental processes do not have mental phenomena or other components that the consciousness mental process can be aware of and experience such that awareness and experiences of what something in these mental processes is like occur. Thus, there is no consciousness of these mental processes. These mental processes are called subconscious or unconscious mental processes [18,104–135]. Mental processes whose mental phenomena the consciousness mental process can be consciously aware of and consciously experience are called conscious mental processes (which differ from the consciousness mental process). It is only the phenomena (or products) of these conscious mental processes, not how they perform their functions, that the consciousness mental process is consciously aware of and consciously experiences [18,76]. For example, the final-stage visual-perception, emotion-generation, and thought-formation mental processes are conscious mental processes because they have phenomena (or products)—mental images, emotions, and thoughts—that the consciousness mental process can be consciously aware of and consciously experience, not because the consciousness mental process can be aware of and experience how these mental processes perform their functions to produce their phenomena. In other words, we are conscious of the products of mental processes, not of their processing processes [18,76].

Mental processes other than those in the above examples are also conscious mental processes if they have phenomena that are consciously experienceable. They can be classified into two groups, C1 and C2, as discussed in Section 3.4. They are listed here again for ease of reading:

C1. Mental processes in the final stages of all external sensory perception processes and of some internal sensory perception processes, such as those in the final-stage visual, auditory, olfactory, vestibular, and visceral pain perception processes, which have phenomena or products that are consciously experienceable, such as mental images, sounds, smells, equilibrioception (sense of balance), and visceral pain.

C2. Mental processes in the final stages of some of the highest-level emotion-cognition-execution processes, such as those in the final stages of emotion-generating, thinking, planning, decision-making, and motor-commanding processes, which have phenomena or products that are consciously experienceable, such as emotions, thoughts, mental plans, decisions, and motor commands.

However, as discussed in Section 3.5, the vast majority of mental processes are unconscious mental processes; they do not have phenomena or any other components that are consciously experienceable, and consciousness does not occur with these unconscious mental processes. They can be classified into two groups, UC1 and UC2, as discussed in Section 3.5. They are also listed here again for ease of reading:

UC1. Mental processes in a) the early stages of all sensory perception, b) all stages of non-sensory stimulus perception, and c) some special situations. Some examples are a) those in the early stages of visual, auditory, and somatosensory perception, b) those in all stages of perception of blood constituent levels, vessel pressure, and reflex stimuli, and c) those in cases of subliminal perception [135–139], binocular rivalry [140–147], attentional blinks [148–154], inattention blindness [155–161], and blindsight [162–165]. We are not aware of and do not experience what something is like in those mental processes.

UC2. Mental processes in a) the cerebral hemispheres except those specified in C1 and C2 and b) all other structures of the nervous system (the brainstem, cerebellum, spinal cord, and peripheral, autonomic, and enteric nervous systems). Mental processes in this group are numerous. Examples include those that function for unconscious attention, unconscious thinking, unconscious reading, unconscious visual perception and face recognition, unconscious mathematical operations, unconscious decision making, unconscious control of muscle tone and motor coordination, unconscious control of spontaneous breathing, unconscious control of cardiac functions and vessel contraction, unconscious control of blood constituent levels, unconscious control of gastrointestinal tract secretions and movements, and unconscious control of all reflexes [18,104–135]. We are not aware of and do not experience what something is like in those mental processes.

II. Because consciousness in the second, third, and fifth meanings has content, it always occurs with other mental processes (i.e., conscious mental processes C1 and C2) that provide the content (e.g., sensory perception, emotion, and thought) for the consciousness. In other words, consciousness never occurs alone in these meanings [93].¹⁶ Therefore, it is possible to view consciousness and the content (provided by the conscious mental processes) as parts of a larger entity, which may be called “consciousness plus” or other comparable terms. However, many still call this larger entity “consciousness,” as in the third and fourth meanings. Because consciousness in this larger form is commonly referred to simply as consciousness, both in the literature and by the media and general public, one must be mindful that the term consciousness found in

¹⁶ Some authors believe that consciousness can occur alone without content and call this type of consciousness “minimal phenomenal experience” (MPE), “consciousness as such,” or “pure awareness” [166–168]. However, this is, at present, controversial.

the literature or media may have this meaning, not the meaning defined by this theory or other definitions.

III. Regarding the operation of consciousness mental processes, it is to be noted that, although, at any moment under normal conditions, consciousness consists of conscious awareness and experiences of several mental phenomena simultaneously, the intensity and accuracy of the awareness and experiences of these mental phenomena are usually not equal. During any period, only one or a few mental phenomena have primary conscious awareness and experiences, whereas others have secondary conscious awareness and experiences. The former have intense and accurate awareness and experiences, whereas the latter have less intense and less accurate awareness and experiences. For example, when we are watching a movie, our primary conscious awareness and experiences will be of the visual perception, auditory perception, and emotions that are movie-related, while our conscious awareness and experiences of non-movie-related sensory perception and emotions, time, etc. will become less intense and less accurate. Even in the case of a mental phenomenon that has the primary conscious awareness and experience, the intensity and accuracy of the awareness and experience of that mental phenomenon are usually not equal for all its parts. For example, the intensity and accuracy of the awareness and experience of an image will be maximal at the center of the visual field but diminish drastically for the periphery of the visual field. Reports of parts that have secondary awareness and experiences are usually inaccurate or sometimes outright wrong. These inaccuracies commonly occur in daily life. Even the reader can notice that the reader cannot accurately describe things that are not in the central visual field, such as the letters that surround the text the reader is reading right now, or cannot accurately report what has happened in the surroundings during the past five minutes while the reader was reading this chapter. Such inaccuracies in secondary conscious awareness and experiences can be demonstrated more objectively in experiments involving phenomena such as attentional blinks, inattention blindness, and change blindness [169–173].

IV. It is undeniable that these kinds of secondary awareness and experience exist and that we are not unconscious of those objects that do not have primary awareness and experiences. Evidently, we can be aware that, apart from the thing at the center of our interest and attention, there is something that we can inaccurately register in the background or periphery—the background and periphery are not blank [174–176]. Obviously, we do not live in a world consisting only of primary awareness and experiences. Because we are conscious of these background objects in the sense that awareness and experiences of what their qualia are like occur in our minds, conscious awareness and experiences *or phenomenal consciousness* must have occurred. However, because we cannot accurately report these background objects in detail, their detailed information does certainly not enter the global workspace to be widely distributed and

used in various ways, as previously discussed in the third meaning of consciousness. Thus, *access consciousness* in the sense that is discussed there (which is the sense used in the Global Workspace or Global Neuronal Workspace Theory [59–70]) does certainly not occur in these kinds of secondary awareness and experience. Nevertheless, if one relaxes the definition of access consciousness and uses it in the sense that some information has gained access to the mind, has been registered, and is at least roughly reportable, *access consciousness* in this relaxed sense must certainly occur for these kinds of secondary awareness and experience.

V. Because the details of objects that we are aware of in secondary awareness can vary from completely wrong to partially correct to almost completely correct, it means that consciousness content in secondary awareness can be present in a graded fashion [177–180]—it does not need to be present in an all-or-none fashion as consciousness content of something that we pay attention to has been shown to be [181,182]. The consciousness content of something in an unattended situation can be degraded by being fragmented (only some parts of that thing being registered), less salient (having less effect on impression, memory, emotion, etc.), too generic (classifiable only in a general category not in a specific category, such as a skittering mouse identifiable only as a small animal), or flash-like (appearing very briefly) [178]. It has been found that, at the representational level, the factors that can affect perceptual representations are the object’s intensity, precision, stability, and availability for working memory [178]. Relatedly, several recent studies have suggested that consciousness can admit of degrees and proposed a graded perceptual awareness scale for objective quantification [24,45].

VI. Another interesting but controversial issue is whether phenomenal consciousness and access consciousness must occur together or whether one can occur without the other [26,32,38,183–185]. In addition, the mechanism for phenomenal consciousness occurring without access consciousness is still being debated, especially the much-discussed one—the overflowing [26,38,186–189]. However, the discrepancy in the occurrence of the two types of consciousness is real and does exist. For example, in the case of the man in the mall discussed previously in the third meaning of consciousness, phenomenal consciousness of the background sound occurs, but access consciousness of the background sound does not. Again, it seems that the discrepancy lies in the definition of “access” in access consciousness (as just discussed in IV). If “access” must involve attention and result in the accessing information becoming globally available, processed in various ways, and reportable in detail (i.e., “access” in the strict sense), then phenomenal consciousness can sometimes occur without access consciousness. On the other hand, if “access” means merely that information about something has gotten into the mind’s processing system, resulting in registration of that thing with at least that thing being roughly reportable (i.e., “access” in the relaxed sense as noted in IV), then phenomenal consciousness always occurs with access consciousness.

6.5 Conscious Alertness and Awareness

Functionally, consciousness in most meanings, including *consciousness*, can be considered to have two major aspects: a) *alertness (wakefulness or arousal)* and b) *awareness and experiences* (registration and feelings of something, which is consciousness content) [4,18,20,21,111, 183–185,190–194]. Alertness depends on a neural network called the ascending reticular activating system (ARAS) [20,102,183,192, 193,195–198], whereas awareness and experiences depend on the consciousness neural circuit (discussed in detail in the next section). The ARAS is a neural network in the core of the brain extending from the rostral pons to the thalami and bilateral basal forebrains, from where it sends extensive axonal projections to the cerebral cortices, including those of the consciousness neural network. There can be no conscious alertness if there is no stimulation from the ARAS, even though the consciousness neural network is intact and able to function, such as in the case of extensive brainstem hemorrhage, infarction, and injury. The level of conscious alertness varies according to the activation from the ARAS—the stronger the activation, the higher the level of alertness. Thus, alertness can vary on a continuum of states, from the lowest to the highest level. Frequently used terms for some of these states, from the lowest to the highest level, are coma, stupor, drowsiness, normal alertness, and heightened alertness.

Regarding the content, conscious awareness and experiences can vary in terms of both the quantity and quality of their content. The quantity of content depends on the extent of the consciousness network function. When there is an impairment of the consciousness network that decreases its functioning extent, such as in cases of cerebral infarction, injury, or hypoxia, the content's quantity will decrease. The extent to which it decreases depends on the extent of the impairment. Thus, like conscious alertness, the quantity of consciousness content can vary on a continuum of states from consciousness with minimal content to consciousness with normal content. Frequently used terms for some of these states, from that with minimal content to that with normal content, are vegetative state/unresponsive wakefulness syndrome (VS/UWS), minimally conscious state (MCS), akinetic mutism [21,90,183,184,191,194,199–213], dementia [214–217], various cerebral neglect syndromes [218–221], and normal consciousness. In the first two categories, which represent severe conditions, patients can open their eyes and have some reflex responses, such as blinking, chewing, and yawning, but show no (in VS/UWS) or minimal (in MCS) signs of conscious awareness of their self and the environment (which can be investigated by clinical testing or by special investigations using EEG, evoked potentials, and fMRI) [21,183,191,194,199,202,203,205,206,222].

Concerning the quality of content, consciousness can vary in its content's quality (or complexity): from consciousness of basic content, such as consciousness of sensory perception, to consciousness of more complex content, such as consciousness of one's own mental activities, to consciousness of even more complex content, such as

consciousness of one's own self and consciousness of being conscious. Several authors call consciousness with these specific kinds of content using specific terms, namely, primary consciousness, higher-order consciousness, and reflective consciousness, as discussed in detail in the third paragraph of Section 6.3. Some authors call these kinds of differences “*different degrees*” or “*different levels*” of consciousness [56,94–96,103], which actually refer to different degrees or levels of *consciousness content quality*. Unfortunately, these phrases can be confused with the *different degrees of awareness accuracy* discussed in Paragraph V of Section 6.4 or with the *different levels of alertness* discussed in the first paragraph of this section. Accordingly, one must be careful about what kind of degree or level is being referred to when the term is used without specification or contextual clues.

These variable abnormalities in consciousness show that consciousness (in most meanings with the probable exception of access consciousness) is not an all-or-none but a graded phenomenon [48,51,85], depending on both the strength of stimulation from the ARAS and the functioning of the consciousness neural circuit. Conventionally, the graded level of conscious alertness and awareness can be scored using various scales, such as the Jouvett coma scale, Glasgow Coma Scale (GCS), Full Outline of Unresponsiveness (FOUR) score, Bozza-Marrubini scale, and Coma Recovery Scale-Revised (CRS-R) [213,223–231].

Presently, many scientists have the opinion that consciousness is a multidimensional phenomenon, having other important aspects, dimensions, or features than the aspects of alertness and awareness [48,206,232–236], such as subjective awareness, cognition, and behavioral aspects [233]; phenomenal, semantic, physiological, and functional aspects [48]; qualitative richness, situatedness, intentionality, integration, and dynamics and stability [206]; p-richness, e-richness, unity, temporality, selfhood, and many other features [44,235]. Thus, they believe that these elements should also be included in the complete assessment of consciousness [44,48,206,233,235]. Another important issue is that measurements of consciousness usually require signaling (e.g., verbal, ocular, or manual) from the patient. This can make consciousness measurements inaccurate if the patient has problems in the motor system that impair signaling. Therefore, objective consciousness measurements that are independent of the subject's signaling ability and cover more than overall alertness and awareness are being developed, such as the perturbational complexity index (PCI), which employs transcranial magnetic stimulation [236–238], and the local global paradigm (LGP) [236,238–240]. However, at present, no method that objectively assesses consciousness in these various facets is standard or widely accepted [48,206,233].

Despite these remarkable developments, it should be noted that this kind of multi-dimensional consciousness comprises various complex perception, emotion, and

cognitive-executive functions, not only alertness, awareness, and experiences. As previously discussed, although these complex functions usually occur with consciousness, they are not *consciousness*, as defined in this theory, which is only awareness and experiences of what qualia are like. Hence, the reader should observe that the proposed consciousness measurements above, although clinically and scientifically valuable in assessing the overall complex brain functions, do not specifically measure conscious awareness and experiences or *consciousness* as the sole target of assessment. This fact must be considered when employing these measurements or interpreting the results.

6.6 Consciousness Neural Process and Circuit

Because the consciousness mental process is a mental process, it cannot occur alone by itself but must occur with some neural process (Theorem I). In this theory, this neural process is called “the consciousness neural process,” and its neural circuit, “the consciousness neural circuit.” Both the consciousness neural circuit and process function to create conscious awareness and experiences, or consciousness, as the consciousness mental process does. From the properties of consciousness, it can be predicted that some important characteristics of the consciousness neural circuit and process must be as follows:

1. The circuit must be an extensive network that connects to all neural circuits that have qualia so that awareness and experiences of all qualia are possible. These qualia neural circuits are neural circuits that function with conscious mental processes (C1 and C2, Section 6.4, which have qualia). However, it is not connected to the lower neural circuits that perform more basic functions, such as neural circuits in the basal ganglia, brainstem, cerebellum, and autonomic nervous system, in such a way that conscious awareness and experiences can occur. Consequently, there is neither conscious awareness nor conscious experience of anything in these neural circuits.
2. It must be able to read signals from the neural circuits that have qualia so that it can obtain the qualia’s information to process and create awareness and experiences of the qualia, i.e., the consciousness of the qualia.
3. It must have its signals fed back to itself so that it can be aware of and experience the created consciousness of the qualia (created as described above), which means its signaling state must be a reentrant signaling state.

Since the consciousness neural circuit and its neural processes are very important in creating consciousness, a large amount of research has been conducted on them. In the field of neuroscience, they are usually referred to as the neural correlates of consciousness. This term is usually described as the minimal neuronal mechanisms that are jointly sufficient for any one specific conscious percept [4,6,26,49,68,75,97,111,125,

193,241–266]. Although conclusive answers have not yet been obtained, some models are strongly supported by experimental evidence and are widely accepted. Regarding the neural circuit of consciousness, as far as one can conclude from the evidence at present, it seems very likely that the default mode network or resting state network, which includes several brain regions—the medial prefrontal cortex, posterior cingulate cortex, retrosplenial cortex, precuneus, and some parts of the parietal lobe, temporal lobe, cerebellum, and basal ganglia—and has the anterior medial prefrontal cortex and posterior cingulate cortex as the hubs, is the neural network for background or resting state consciousness [190,267–288]. This network functions to create consciousness for usual background stimuli, both external and internal, that enter the mind concurrently and continuously and do not require specific attention and concentration. It overlaps with the network that functions to create consciousness for episodic stimuli that gain access to the mind at times and attract specific attention [4,8,10,12,16,18,22–25,32,38–43]. At present, evidence shows that the network of the Global Workspace Theory proposed by Baars [59–64] or the network of the Global Neuronal Workspace Hypothesis of Dehaene [65–70], both of which include a cortico-thalamic (C-T) core and a network of neurons with long-range axons densely distributed in the prefrontal, fronto-parietal, parieto-temporal, and cingulate cortices, is the network of this latter kind of consciousness, which is usually called access consciousness. Other studies point to similar networks that are in the superior parietal and dorsolateral prefrontal cortices [244,265,289], but others stress the posterior hot zone more, including the temporal, parietal, and occipital cortices [245,256]. Specifically, in the case of vision, ample evidence shows that cortical neural synchronization between neural processes in the occipital areas and parietal, temporal, or frontal areas is necessary for visual conscious experiences to occur [67,97,244,260,265]. Also, there are separate neural correlates for the visuospatial, emotional face, and written-letter processing components; that is, cortical neural synchronization between the dorsal occipital and parietal areas, between the parietal and frontal areas, and between the occipital, parietal, and temporal areas, respectively [97]. As for the complete neural network of consciousness, the one that functions to be conscious of both continuous background stimuli and episodic accessing stimuli, it is likely to be some combination of the two types of consciousness networks just discussed. Some proposed networks are the neural network in the extended theory of global workspace of consciousness submitted by Song [71], the overlapping network of a-consciousness and p-consciousness with two functional aspects introduced by Frigato [290], or the “functional rich club” presented by Deco et al. [291].

Finally, it should be repeated that the functions of the two major consciousness networks—one for episodic, attention-demanding stimuli and the other for continuous, non-attention-demanding stimuli—are not mutually exclusive. That is, the two consciousness networks do not work alternately in such a way that one is completely shut off while the other is working. For example, when the former network is functioning,

such as when a subject in a consciousness experiment is attending to a visual stimulus on a screen, the latter network is still functioning, as evidenced by the fact that the subject is still aware of not only the target or the masks he or she is attending to but also other parts of the experiment (e.g., the signaling device that he or she must use and when and how he or she is supposed to signal) and the surroundings (e.g., the background vision, the ambient sound, and the room's smell). Evidently, the subject can use the device to signal as he or she is supposed to and can later report some of the surroundings' characteristics, which means he or she is aware of not only the target but also something else. However, the awareness of these background components is less intense and less accurate than that of the attended stimulus, and these background components cannot be reported in detail or with accuracy. Still, it is not that, while the mind is attending to something, such as the target in an experiment, it is not aware of anything else at all and that everything else vanishes [174–176]. Undeniably, we regularly have similar experiences in our daily lives. For example, when we are concentrating on listening to a song or to what somebody is speaking to us on the phone, the outside visual world does not disappear into nothingness even though we do not pay attention to it—we are still conscious of it to some degree and, hence, can describe it, at least roughly. It is of paramount importance that, in searching for the complete consciousness neural network, these facts must be taken into account.

6.7 Remarks

In conclusion, consciousness has various meanings. This theory selects to use consciousness in the meaning defined in Section 6.1 because consciousness only in this meaning is the one that makes us different from AI and that is the crux of the hard problem and the explanatory gap of consciousness, which this theory aims to resolve.

The next chapter will answer fundamental questions about what this consciousness is physically and ontologically, why it occurs, how it occurs from physical systems, and other related questions.

*Among all the things that happen in the mind,
the only one thing that makes us
fundamentally different from AI
is awareness and experiences of
what an image of a house, what a sound of a song, what an
odor of a flower, what a feeling of happiness, what a thought
of oneself, and so on
are like ...
the phenomenal consciousness.*

Chapter 7

Theorem V: Consciousness is a Signaling State

As discussed in the previous chapter, consciousness in this theory is conscious awareness and conscious experiences, or awareness and experiences of what qualia are like, such as awareness and experiences of what an image of a house, a sound of a song, and an odor of a flower are like. It is not the complex mental functions that are responsible for our intelligence and abilities, although they are frequently conflated with it. The merging happens because it does not occur in isolation but always with them. Therefore, it is very important to note from the beginning of this chapter what kind of consciousness this theory attempts to investigate.

As the basic components of consciousness in this theory are conscious awareness and experiences, it is necessary to determine the nature of conscious awareness and experiences first. This can be done as follows:

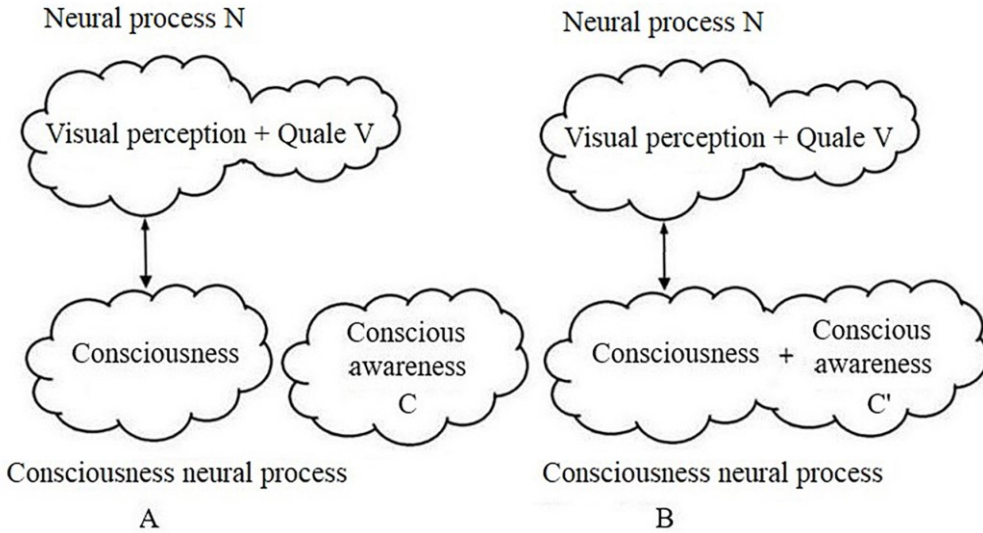
7.1 The Nature of Consciousness

Based on Chapters 3 to 5, we know that, after the consciousness neural process reads the signaling pattern of a neural process that has a quale, conscious awareness and a conscious experience of the quale occur. But what are they? Are they separate entities from the consciousness neural process or intrinsic entities within it, and what are they physically and ontologically?

Let us first investigate conscious awareness. Suppose conscious awareness is an entity C that functionally occurs separately from all neural processes (Figure 7.1A). As conscious awareness is a quale (because it is consciously experienceable), when we investigate entity C in the same manner as we do entity Q of Possibility I in Section 5.1.1, we will find that C faces similar problems as Q and that these problems lead to the same conclusions. Therefore, it is unnecessary to spend time repeating the entire investigation process but sufficient to go over only some important problems before drawing a conclusion. The major problems that C encounters are as follows:

#1. What is the nature of C? Based on observation, it seems to be non-material; however, what is the exact nature of this non-material entity? Currently, there is no answer to this question, and a new hypothesis regarding the nature of this entity is needed.

#2. How can C occur? The questions regarding its occurrence are like those regarding Q's occurrence. For example, if C occurs from the consciousness neural process, how



A visual perception neural process N produces visual perception and a visual quale V and sends their information to the consciousness neural process via its signaling pattern; conscious awareness (C or C') of Quale V then occurs.

Figure 7.1 Conscious awareness occurs separately (C) or intrinsically (C').

does the consciousness neural process produce it? A neural process does not have an apparatus to produce anything that can contain signals or information except its signaling pattern, signaling state, and electromagnetic activities, all of which occur intrinsically in the neural process, not separately from it as this hypothetical C does. However, if it does not occur from the consciousness neural process, what is the entity that creates it, and how can this entity know when and where to create C? If C occurs out of nothing by itself, how can it do that, and how can it know when and where to occur? New hypotheses are required to address these problems.

#3. To be conscious awareness of Quale V, C must first have information about Quale V so that it can be conscious awareness of Quale V. For example, to be conscious awareness of an image quale of a house, C must first have information about the image quale of the house. However, if C is functionally separate from all neural processes, it cannot get the information about Quale V through the consciousness neural process, Neural Process N, or any other neural processes. Therefore, a new hypothesis for how C can get the information about Quale V is needed.

#4. Because we are aware of the conscious awareness C that has occurred, the consciousness neural process must be able to read the signals from this functionally separate C so that it can be aware of C. However, if C is an entity that occurs separately

from all neural processes, its signals cannot be E/EC signals and must be something else. What is the nature of these signals, and how can the consciousness neural process read signals that are not E/EC signals and are functionally separate from it? New hypotheses for these problems are needed.

Evidently, the possibility that conscious awareness is a functionally separate entity from all neural processes raises several critical questions that currently have no answers, and several new hypotheses are needed to support it. This is also true for the possibility that a conscious experience is a functionally separate entity from the consciousness neural process.

Now, let us examine the possibility that the conscious awareness of Quale V occurs intrinsically in the consciousness neural process as C' in Figure 7.1B. Although consciousness has been proposed to have many functional properties such as allocentricity [1,2], complexity [3,4], dynamicity [1,5–7], global availability and effects [1,5,7], immediacy, independence, indescribability [2], integration [8,9], intentionality [3,4,6], perspectivalness [2,4–7], phenomenality [2,5–7,10], privacy [4,11,12], reportability [1,4], subjectivity [1,4,6,12,13], temporal continuity [13], transparency [5,7], and unity [4,6,9,10,11,13], the physical nature of the conscious awareness C' can simply be found from the fact that we can be consciously aware of and consciously experience C'—we can be aware of and experience its occurrence and what it is like in our mind. This means that C' must be consciously experienceable; hence, it must be a quale, as noted earlier. Because it is a quale, we can prove in the same way as we did for qualia in general in Section 5.1.2 that conscious awareness is the consciousness neural process's special signaling pattern (SSP). This can answer all questions that the case of C cannot, as follows:

#1. The nature of C' is that it is an SSP, which is a type of neural signaling pattern or neural information. Since a neural signaling pattern or information is a known entity, C' is not a novel entity; thus, a new hypothesis to account for C' is not needed.

#2. C' occurs by the consciousness neural process creating an SSP with information that means conscious awareness of Quale V to the consciousness neural process itself as follows: After the consciousness neural process reads Neural process N's signaling pattern, which has information about Quale V, it processes this information and then, with its specialized ability, incorporates this information into a new signaling pattern—an SSP—that has the information that means conscious awareness of Quale V to the consciousness neural process itself. This new signaling pattern, the SSP, is C'.

#3. C' contains information about Quale V as discussed in #2.

#4. The consciousness neural process can read the signals from C', which is its own signaling pattern by the process of reentrant signaling, and thus can become aware of C'.

In other words, the SSP of C' is fed back to the consciousness neural process. This type of reentrant signaling is not exceptional; it is common in the nervous system and occurs in many other neural processes [14–17].

Therefore, that conscious awareness is *the consciousness neural process's SSP having information that means conscious awareness of Quale V to the consciousness neural process itself* readily explains everything without requiring a new hypothesis. This is similarly true for a conscious experience of Quale V. Accordingly, this theory proposes that conscious awareness and a conscious experience of a quale are the consciousness neural process's SSPs that have information that means conscious awareness and a conscious experience of the quale, respectively, to the consciousness neural process itself.

The next question concerns the nature of consciousness. Because consciousness is defined as the composite of all conscious awareness and conscious experiences, it is the composite of all SSPs with information about conscious awareness and conscious experiences of all qualia present, including consciousness itself (because consciousness is one of the qualia that are present). Accordingly, the composite that consciousness is must be a form of signaling pattern that makes this possible. Let us examine how this is possible as follows:

Again, for simplicity, let us analyze conscious awareness and a conscious experience separately. Consider *the conscious awareness of Quale V* (C' in Figure 7.1B), which is now proved to be the consciousness neural process's signaling pattern that has information about conscious awareness of Quale V. Next, a new, secondary conscious awareness—conscious awareness of *conscious awareness of Quale V*—occurs after the consciousness neural process reads and processes the signaling pattern of *conscious awareness of Quale V* by the process of reentrant signaling. It is possible that reentrant signaling occurs repeatedly and that additional (tertiary and higher) conscious awareness occurs. In any case, finally, the consciousness neural process will reach a stable state that has circulating signals having information that means the unified conscious awareness of both *Quale V* and *conscious awareness of Quale V* to the consciousness neural process itself because we feel them unified and not fragmented in multiple pieces of conscious awareness. In addition, in this stable signaling state, the signal that is read by the consciousness neural process, passes through the consciousness neural process, comes out as its products, and is re-routed to be re-read, must be information-wise, the same signal (that is, no additional changes occur) because we feel the unified awareness as stable and not changing. This is also true for the conscious experience of Quale V.

Therefore, in the final stable reentrant signaling state, the signals circulating in the consciousness neural process are stable and have information about the conscious awareness and experiences of both *Quale V* and *conscious awareness and experience of Quale V*. This is true for all other qualia that are occurring. Thus, normally, the signaling

state of the consciousness neural process has information about conscious awareness and experiences of both *all occurring qualia* and *conscious awareness and experiences of all occurring qualia*. This theory asserts that, physically and ontologically, ***consciousness is this stable reentrant signaling state*** of the consciousness neural process. This concept is similar to those in many current theories of consciousness [1,14,18–29].

7.2 Theorem V

However, reentrant signaling states also occur in many other neural processes [14–17], but, unlike in the consciousness neural process, conscious awareness and experiences do not occur in them. This means that reentrant signaling states in other neural processes do not have information that means conscious awareness and experiences to those neural processes, whereas some reentrant signaling states in the consciousness neural process have information with this meaning. Thus, this theory will assign the term “special signaling state” or “SSS” to this kind of reentrant signaling state that has information that means “conscious awareness and a conscious experience” to the consciousness neural process.

Definition: A special signaling state (SSS) is a reentrant signaling state with information that means conscious awareness and a conscious experience to the consciousness neural process.

Because of its meaning, when an SSS is read by the consciousness neural process through reentrant signaling, it appears to be conscious awareness and a conscious experience to the consciousness neural process. Hence, conscious awareness and a conscious experience naturally and inevitably appear in the consciousness neural process and the brain.

Based on the above definition, a composite of *all SSSs* is a composite of *all reentrant signaling states with information that means conscious awareness and conscious experiences to the consciousness neural process*. Evidently, this composite has the overall information that means *all conscious awareness and conscious experiences to the consciousness neural process*. Now, according to the definition of consciousness (Section 6.1), consciousness is all conscious awareness and conscious experiences. Therefore, the above composite contains information that means consciousness to the consciousness neural process. Thus, when this composite is read by the consciousness neural process through reentrant signaling, it is interpreted as such, and consciousness naturally and inevitably appears in the consciousness neural process and the brain. Because this composite appears as consciousness in the brain, this theory asserts that it is consciousness, and vice versa. This is the assertion of Theorem V of this theory.

Theorem V: Consciousness is the composite of all special signaling states (SSSs).

The term special signaling state can be re-expanded to understand the true meaning of consciousness:

Consciousness is the composite of all *reentrant signaling states with information that means conscious awareness and conscious experiences to the consciousness neural process*.

The terms conscious awareness and conscious experiences can also be re-expanded to make it clearer:

Consciousness is the composite of all *reentrant signaling states with information that means awareness and experiences of what qualia are like to the consciousness neural process*.

However, the composite of all SSSs is just a special kind of signaling state, and a special kind of signaling state is just a signaling state. Therefore, a more and the most basic form of Theorem V can be stated respectively as:

Theorem V: Consciousness is a special kind of signaling state.

Theorem V: Consciousness is a signaling state.

In plain language, this theorem means that awareness and experiences of what qualia are like (what an image of a house, a sound of a song, an odor of a flower, a feeling of happiness, a thought of one's self, and so on are like) in our minds are simply a special kind of signaling state or, most basically, a signaling state in our brains.

Because a neural process's signaling state is the neural process's information that exists in that neural process, consciousness is a special type of neural process information existing in the consciousness neural process. This special type of information means all awareness and experiences of what qualia are like to the consciousness neural process itself.

The fundamental question is: How is it possible that a special signaling state and its information can have such a meaning—*the meaning of awareness and experiences of what qualia are like*? The answer is that it is a brute fact. In this universe, it is basically possible for some signaling states and their information to have such a meaning. During evolution, countless types of signaling states have evolved in the nervous system, with uncountable kinds of information and meanings for neural processes to perform various functions. SSSs are just signaling states that have evolved to be a new kind of information that means awareness and experiences of what qualia are like for a new function—to be

aware of and experience what qualia are like—to be possible in a new kind of neural process, the consciousness neural process. To an outside observer who sees an SSS from a third-person point of view, it does not and cannot appear as consciousness because its information is not read and interpreted—it is merely looked at. On the contrary, to the consciousness neural process, an SSS can and must appear as consciousness because its information is read and interpreted. This interesting and important matter will be revisited and discussed in detail in Chapter 8: The Explanatory Gap.

Therefore, physically and ontologically, consciousness is neither a new physical entity nor a novel non-physical entity but just an underrecognized part of a well-recognized physical entity. It is the signaling state of a neural process—the inherent, informational part of a physical process. Because signaling states are inherent in neural processes, nothing in the brain emerges to be consciousness [10,30,31]. It seems as if something emerged to be consciousness only because SSSs have new information—the information that *means awareness and experiences of what qualia are like*—while other signaling states do not. Yet they also have their own information; it is only that their information means something else. To reiterate this crucial point, signaling states and information are inherent in neural processes; only the evolution of their meanings into “consciousness” makes it look as if something (consciousness) emerged. Since the nervous system appeared, new signaling states with new information, meanings, and functions have constantly been evolving from old signaling states with old information, meanings, and functions, with no novel entities emerging in the process. This fact has always been true and, according to all the evidence we have, will always be.

7.3 Physical Effects of Consciousness

Similar to qualia, which have been shown in Section 5.3 to have physical effects, consciousness has physical effects. This is because it is a signaling state, so it can affect the neural process itself. Also, it can convey its information to other neural processes, thereby affecting them. This matter can be investigated in more detail as follows:

Consider two integration-center neural processes as depicted in Figure 7.2. The integration-center neural process A (IC-A) receives information from various neural processes, analyzes and integrates information, and distributes processed information to appropriate neural processes. It may also have unconscious awareness of these functions, but it does not have conscious awareness and experiences; that is, awareness and experiences of what these functions, their products, or their other components are like do not occur in IC-A, like the cerebellum or present-day computers.

On the other hand, the integration-center neural process B (IC-B) performs the same functions as IC-A, but, in addition, it has conscious awareness and experiences. That is, awareness and experiences of what the products of the mentioned functions above are like

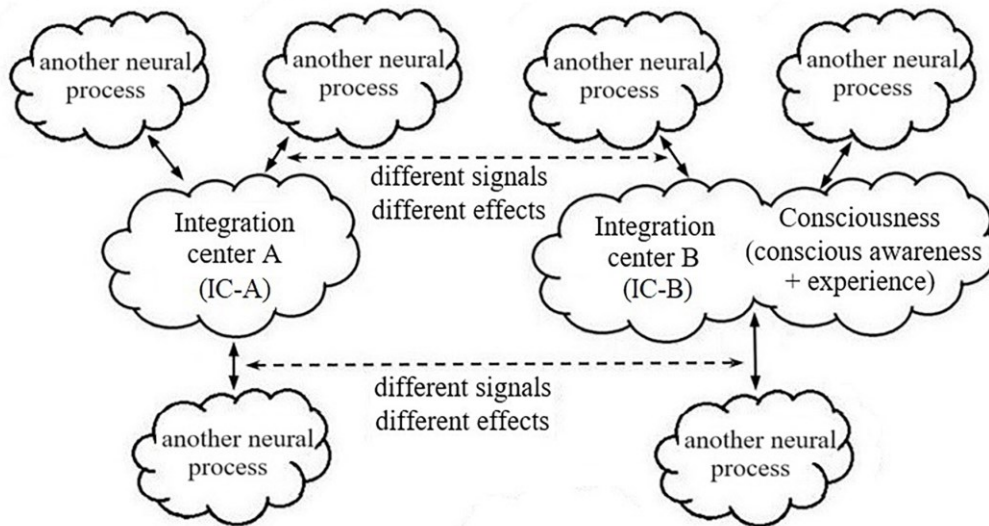


Figure 7.2 Effects of integration centers without and with consciousness

occur in IC-B. Thus, IC-B has information about conscious awareness and experiences of these functions in its process, whereas IC-A does not. As IC-A and IC-B have different information, they have different signaling states. When they send their information to other neural processes, IC-B can send signaling patterns that contain information about conscious awareness and experiences to them, whereas IC-A cannot. Consequently, the physical effects on other neural processes must be different, at least when IC-B sends signaling patterns with such information, which IC-A cannot send.

Moreover, the physical impact of each signaling state on its own neural process is different because different signaling states entail different production, operation, and maintenance processes, which expend different physical resources. Thus, apart from the different effects of conscious awareness and experiences—i.e., consciousness—on other neural processes, having consciousness in a neural process also has specific physical effects on the neural process itself. Therefore, a system with consciousness is physically different from a system without it.

At present, we still cannot definitively conclude from existing research and studies what the physical effects of consciousness are. However, evolving anything (such as evolving the integration center) by adding a new function (such as consciousness) must cost resources (such as material, energy, and time to build and maintain the new circuit, process, and signal). If the new function does not yield sufficient beneficial effects to make its overall effects advantageous to the being, the new function will result in a disadvantage for that being and its species. This basis is especially true in the case of a

major function in a crucial organ, such as in the case of consciousness in the brain. The species will likely be losing from this disadvantage and, during evolution, will become extinct due to competition with species that are similar but do not have that new function, such as the original species. However, this kind of extinction has not happened to humans, which possess consciousness, or to many high-level animal species that may have consciousness (because they have evolved similar brain structures to those supporting consciousness in humans [32–47]). Instead, these species appear to be thriving. Therefore, it can be deduced that consciousness must have overall effects that are beneficial to the beings that possess it. Similar to the effects of qualia on perception, it is probable that consciousness augments the functions of conscious mental processes so that they become more effective in certain ways.

At this point, it should be noted that the effects of consciousness have been widely studied and discussed in both cognitive neuroscience and philosophy. However, the definitions of consciousness in these studies are not always the same. Usually, in the literature on the effects of consciousness, the term consciousness has either the third or fourth meaning of consciousness discussed in Section 6.2. Consciousness in these two meanings has been found to have various beneficial effects, such as enabling us to solve problems that unconscious processes cannot, to have non-reflexive, flexible behavior, and to gain insight into the minds of others by illuminating our own workings [1,6,10,21,31,41,44,48–60]. However, because of differences in definitions, these effects are not proven effects of consciousness as defined in this theory, which is awareness and experiences of what qualia are like. Therefore, although beneficial, these reported effects cannot be claimed to be effects of consciousness as defined in this theory.

Lastly, it should also be remarked that consciousness certainly not only has beneficial but also deleterious effects. Some authors have pointed out that consciousness's seemingly beneficial effects are probably not enduring—it may be beneficial in the present ecosystem but disadvantageous in another. Thus, it is possible that consciousness itself is not intrinsically valuable and that its overall effects depend on external factors. However, this matter is still debatable [see References 61–63].

7.4 Predictions

1. Consciousness will be found to occur with a certain neural process—it will not be found to occur without this neural process. This means that, when and where there is consciousness, the neural process that the consciousness is completely associated with will be found then and there.

Note. A neural process can be identified as this particular neural process by investigations that observe and may also manipulate potential neural processes concurrently with observing the consciousness in question. In various investiga-

tions, the neural process that consistently changes concomitantly and correspondingly with the consciousness will be that particular neural process, named the consciousness neural process.

2. This neural process will be found to have connections to all neural processes that have qualia, to have its signals fed back to itself, and to have, when it functions to be conscious of something, a signaling state that is categorically different from other signaling states of other neural processes. This signaling state is called a special signaling state (SSS).
3. Consciousness can be identified, quantified, or monitored by identifying, quantifying, or monitoring, respectively, only the composite of all SSSs. These actions on the composite are both necessary and sufficient for the corresponding consciousness investigations to result, while these actions on anything else without involving the composite will not result in the corresponding consciousness investigations.
4. Consciousness can be created, modified, tested, or destroyed by creating, modifying, testing, or destroying, respectively, only the composite of all SSSs. These actions on the composite are both necessary and sufficient for the corresponding actions on the consciousness to occur, and these actions on anything else without involving the composite will not result in the corresponding actions on the consciousness.
5. In an event or experiment, all predictions that are valid for the composite of all SSSs, such as whether the composite will occur, change, or disappear, will be identically valid for the consciousness. That is, the changes that occur in the composite and those in the consciousness will be identical in all aspects (quality, quantity, temporal pattern, etc.). For example, if it is predicted that the composite of all SSSs will change abruptly from the composite involving vision, hearing, and thinking to the composite involving only emotion, it will be found that the changes in the consciousness will be identical in all aspects, such as identical changes from consciousness of vision, hearing, and thinking to that of emotion (quality) and from consciousness of three things to that of only one thing (quantity), and identical abruptness in changes (temporal pattern).

All the above predictions can be verified by experiments in conscious, communicative human subjects. A typical experiment is to monitor consciousness by having the subject report what happens to his or her consciousness while concomitantly monitoring the composite of all SSSs of the subject's consciousness neural process by methods such as MEG, ECoG, and intracortical recordings and while the composite is being manipulated such as by drug administration or transcranial magnetic or electrical stimulation.

7.5 Remarks

At present, there is a great deal of research and many theories about consciousness, but they use varied consciousness definitions, aim to explain different aspects (anatomical, functional, phenomenological, etc.), and employ different investigation methods (experimental, philosophical, psychological, etc.) [6,64–67]. One of the most active and interesting topics is the neural correlates of consciousness—the minimal neuronal mechanisms that are jointly sufficient for any one specific conscious percept [1,14,18–22,24–27,68–93]. This topic has attracted substantial research and discussion, and various theories have been generated. Many theories about consciousness and its neural correlates involve the concept that consciousness arises from the integrated activities of widespread cortical and subcortical areas with bottom-up and top-down signaling, reentrant information processing, synchronous electrical oscillatory activities, and resonant states in the gamma frequency range (30–70 Hz). Examples of these theories are as follows: *A Neurobiological Theory of Consciousness* [76,77], *The Neuronal Basis for Consciousness* [94], *The Neural Darwinism hypothesis* or *Theory of Neuronal Group Selection (TNGS)* [1,14,21,22], *The Global Workspace Theory* [95–100], *The Global Neuronal Workspace Hypothesis* [20,101–105], *An Extended Theory of Global Workspace of Consciousness* [106], *The Adaptive Resonance Theory (ART)* [107–110], and *Recurrent Processing Theory* [17,111,112]. Other theories encompass a range of concepts. For instance, *The Integrated Information Theory (IIT)* entails the integration of information [9,113–117], *The Orchestrated Objective Reduction (Orch OR) Theory* centers on the principle of quantum vibrations within microtubules in brain neurons [118–121], *The Operational Architectonic* embraces the notion of levels of brain operational organization [122–124], and *The Conscious Electromagnetic Information (Cemi) Field Theory* as well as *the Electromagnetic Field Theory of Consciousness* links consciousness to the brain's electromagnetic information field [125–128]. Additionally, there are many theories and hypotheses that try to explain consciousness in various other aspects using various other concepts [such as References 129–144]. Some of the frequently cited theories have been reviewed by several authors [such as References 6,64,66,67,145–147]. As it is not an objective of this theorem to review and discuss existing theories of consciousness or its neural correlates in detail, the author would like to refer interested readers to the cited references.

Regarding the physical and ontological nature of consciousness, which this theorem asserts to be a special kind of signaling state or simply a signaling state, there were similar concepts before. That is, the concept that consciousness is a kind of brain process or activity, like a signaling state in this theorem, had existed before this theory was developed. For example, *Place (1956)* said that consciousness is a process in the brain and can be identified with a pattern of brain activity [148]; *Feigl (1958)* said that consciousness is identical with certain (presumably configurational) aspects of the neural

processes [149]; *Lamme (2006)* said that we could even define consciousness as recurrent processing [24]; *Thagard and Stewart (2014)* said that consciousness results from three mechanisms, the first one of which is representation by firing patterns in neural populations [141]; *Dehaene (2014)* said that consciousness lives in a loop and that reverberating neuronal activity, circulating in the web of our cortical connections, causes our conscious experiences [77]; lastly, *Loorits (2014)* said that consciousness as a whole can be seen as a complex neural pattern and that the phenomenal consciousness simply is a certain complex pattern of neural activity, a pattern of patterns of some simple neural events, and he proposed that the entire structure of consciousness will be discovered in some patterns of neural activity [150]. For more specific discussions, let us consider reentrant signaling states. The present theorem asserts that a certain special kind of them, the SSS, is consciousness. Many theories (in the previous paragraph) have proposed very similar concepts. Notably, the concept in the present theorem is almost identical to that in *The Adaptive Resonance Theory (ART)* [107–110], which states that all conscious states are resonance states. The ART provides comprehensive and strong evidence-based accounts and explanations regarding which resonant states can become conscious, why not all resonant states become conscious, and why all conscious states must be resonant. However, the ART and other theories that have the concept that reentrant signaling states or complex patterns of neural activities are consciousness or essential in consciousness occurrence do not provide a solid rationale for how and why phenomenality should occur in these resonant states or complex patterns of neural activities. In these theories, phenomenality and phenomenal consciousness “just occur” in these material neural networks, resonant states, or patterns of neural activities [151].

On the other hand, the present theorem presents the required rationale: Special signaling states (SSSs) are the information that means phenomenal consciousness to the consciousness neural process that is reading these signaling states, and, because of their meanings, they are interpreted as such—phenomenal consciousness thus naturally and inevitably occurs in the consciousness neural process and the brain. The answer to how it is possible that signaling states can be information having such a meaning is that it is fundamental in the nature of signaling states that some of them, the SSSs, can be such information. It is a brute fact. Some signaling states are information that means phenomenal consciousness to the consciousness neural process, and SSSs simply are such signaling states. Moreover, the reason why SSSs emerged or, to be precise, evolved in the nervous system is just because that was evolutionarily possible. When the nervous system had evolved to a sufficiently advanced stage, it was possible to evolve new neural circuits and processes that were able to produce SSSs. At present, the reason why SSSs persist is likely because they can yield advantages to the animals that have them.

As for the concept that consciousness is a kind of information, this is not a novel idea either. Several researchers have proposed this before. For example, *Earl (2014)* said that

“consciousness is solely information in various forms.” [51], and **Dehaene et al. (2001)** said that “this global availability of information through the workplace is what we subjectively experience as a conscious state.” [103]. Other theories such as **The Double-aspect Theory of Information** [152,153] or **The Dual-aspect Theory of Information** [59,154], **The Integrated Information Theory (IIT)** [9,113–117], **The Conscious Electromagnetic Information (Cemi) Field Theory** [125–127], and a new (2020) theory of consciousness, **The Information Closure Theory of Consciousness (ICT)** [155], have also proposed similar concepts.

In The Double-Aspect Theory of Information, **Chalmers (1995)** explained that “there is a direct isomorphism between certain physically embodied information spaces and certain phenomenal (or experiential) information spaces” and formed a hypothesis that “Information (or at least some information) has two basic aspects, a physical aspect and a phenomenal aspect. ... Experience arises by virtue of its status as one aspect of information, when the other aspect is found embodied in physical processing ... We might say that phenomenal properties are the internal aspect of information.” [152]. Regarding the Integrated Information Theory (IIT), **Tononi et al. (2004–2016)** proposed that a conscious experience is a maximally irreducible conceptual structure (MICS), which corresponds to a local maximum of integrated conceptual information (or a local maximum of Φ or $\Phi^{\max}$) [9,113,116,117]. The IIT uses these quantities to successfully predict which system is or is not conscious in a variety of cases, such as not being conscious during sleep, generalized seizures, or in the cerebellum. Mathematical methods and formulas to calculate Φ have been proposed [113–116,156], and, although these methods and formulas are complex and difficult, actual calculations have been attempted in human subjects [157–158]. However, the IIT does not provide rationales for why such MICS, which correspond to a local maximum of Φ , should become a phenomenal conscious experience or why phenomenality should occur in MICS [159,160]—phenomenality and phenomenal consciousness simply occur in MICS. Recently, **Dubrovsky (2019)** proposed that “... SR [subjective reality] phenomenon (for example, my sensory image in the form of visual perception of some object A, experienced at a given interval) can be considered as information (about this object) ... it has its own definite carrier ... Thus, the phenomenon of subjective reality is necessarily related to an appropriate brain process as information to its carrier.” [161]. Also, **Chang et al. (2020)** theorized in the Information Closure Theory of Consciousness (ICT) that consciousness comprises processes that form non-trivial informational closure (NTIC) but does not explain why such NTIC should have phenomenality [155].

On the other hand, this theorem asserts that information in specific forms—the SSSs, which are very likely to be highly complex but are not required by the theorem per se to be so—means phenomenal consciousness to the consciousness neural process. Thus, when the consciousness neural process reads this kind of information, it interprets it as phenomenal consciousness, not anything else, and phenomenal consciousness naturally and inevitably appears in the consciousness neural process and the brain. Therefore, the

most crucial factor that determines whether any information is or can be phenomenal consciousness is the meaning, not the complexity, of the information.¹⁷

Concerning predictions, the predictions of this theorem conflict with or are not the same as those of some important theories in the preceding paragraphs. For example, *the Orchestrated Objective reduction (Orch OR) Theory* [119–122] proposes that consciousness arises at the quantum level from quantum vibrations of microtubules inside brain neurons; therefore, experiments that significantly affect the proposed quantum vibrations without significantly affecting anything else should significantly affect consciousness. In contrast, Theorem V predicts that a) experiments significantly interfering with the signaling state of the consciousness neural process without or without significantly interfering with the quantum vibrations of the microtubules in the brain will significantly affect consciousness and b) experiments significantly interfering with the quantum vibrations of the microtubules without or without significantly interfering with the signaling state of the consciousness neural process will not or will not significantly affect consciousness. Therefore, such experiments enable us to assess which theory is incorrect. At present, however, it is obvious from clinical and experimental evidence that consciousness can be changed predictably by macroscopic interference with the brain signaling through mechanical, electrical, magnetic, or pharmacological interventions, without microscopic interference of microtubules at the quantum level. Even in daily-life events, the evidence contradicts the Orch OR Theory. For example, when one watches a movie and the information in the form of images and sounds enters the nervous system, one's conscious visual and auditory content changes concurrently with and correspondingly to the movie's information; however, the quantum vibrations of the visual and auditory neurons' neural tubules cannot change concurrently with and correspondingly to the input information because there is no mechanism to convey the outside information to the neural tubules, which are inside the neurons. Thus, this everyday-life evidence demands explanations from the Orch OR Theory for how the quantum vibrations of neural tubules can correspond to consciousness, at least in one of the most important aspects—the content aspect of consciousness.

¹⁷ Information can be very, very complex but unable to be consciousness because it does not mean consciousness to the consciousness neural process and is thus not interpreted as such—consciousness hence does not and cannot appear in the brain. Remember, the word “*pneumonoultramicroscopicsilicovolcanoconiosis*” does not mean consciousness to English-speaking people; on the other hand, because of its meaning, the word “*consciousness*” does, even though it is much shorter and much less complex. Also, from an evolutionary point of view, it seems more reasonable that the nervous system would evolve to respond to the meaning of information, which has definite survival value, rather than to the complexity of information, of which the survival value is questionable.

Various differential experiments can be performed to verify the predictions of this theory against those of other theories. For example, experiments that can significantly affect the composite of SSSs without significantly affecting $\Phi^{\max}$ in that brain area will be able to differentiate the validity of this theorem against that of the IIT. According to this theorem, consciousness will be significantly affected by such experiments, but according to the IIT, consciousness will not be significantly affected. Differentiating between this theorem and the ART [107–110] is the most difficult because of the very similar concepts of both theories. The exact characteristics of the reentrant signaling states and the resonant states that are consciousness must be known to differentiate the two theories. If these characteristics are as predicted by this theorem—all SSSs have the same special form that is categorically different from those of other signaling states—this theorem will be validated. However, if these characteristics are as predicted by the ART, the ART will be validated. The results of such differential experiments, no matter what they may be, will undoubtedly help us understand consciousness more comprehensively. They will assist us in refining existing consciousness theories to achieve the complete consciousness theory someday.

*Like a spectrum of electromagnetic waves,
of which some frequencies do not elicit
color perception in the brain,
but some do,
In a spectrum of information,
some information does not elicit
qualia and consciousness in the brain,
but some does.
Qualia's and consciousness's information
are the parts of an information spectrum
that do.*

Chapter 8

The Explanatory Gap

In Chapters 5 and 7, it has been shown that qualia are neural signaling patterns and that consciousness is a neural signaling state. However, how can such physical signals, which basically result from movements of ions and molecules, give rise to qualia (such as an image of a house, a sound of a song, and an odor of a flower in our minds) and consciousness (awareness and experiences of what qualia are like, such as what an image of a house is like, what a sound of a song is like, and what an odor of a flower is like)? In short, how can qualia and consciousness occur from a physical system? This problem seems to resist scientific explanation and is widely known as the explanatory gap [1–19]. This chapter answers this question, which can be achieved using two different approaches: the information-meaning approach and the point-of-view approach.

8.1 The Information-Meaning Approach

8.1.1 The meaning of various signals

Let us consider various signals with different information, as depicted in Figure 8.1.

First, consider Figure 8.1A. The information of the signal means “a house” to those who understand sign language. When those people read this signal, they will get the information meaning “a house” (the information that means “a house”) from the signal, but only “a house” without anything else, such as what the house looks like. Others, who do not understand sign language or, equivalently speaking, those to whom the signal does not mean “a house,” will not get information meaning “a house” from the signal but will get something else, such as something funny or meaningless.

Likewise, consider Figure 8.1B, which depicts a signaling pattern of a certain subconscious neural process, such as some subconscious visual perception neural process. The information of this signal means “a house” to some receiving neural processes. It may also comprise physical information, such as the size, shape, and color of the house. However, if the whole information does not include information meaning what the house looks like to the receiving neural processes, these neural processes will get the information meaning “a house” and potentially some physical information when they read this signal but no information meaning what the house looks like. Consequently, what the house looks like will not and cannot occur in them. Similarly, awareness and an experience of what the house looks like, which require prior information about what the house looks like, will not and cannot, either. Other receivers that cannot interpret this signal or, equivalently speaking, those to which the signal does not mean “a house” will not get any specific information from it. To them, the signal will be meaningless.

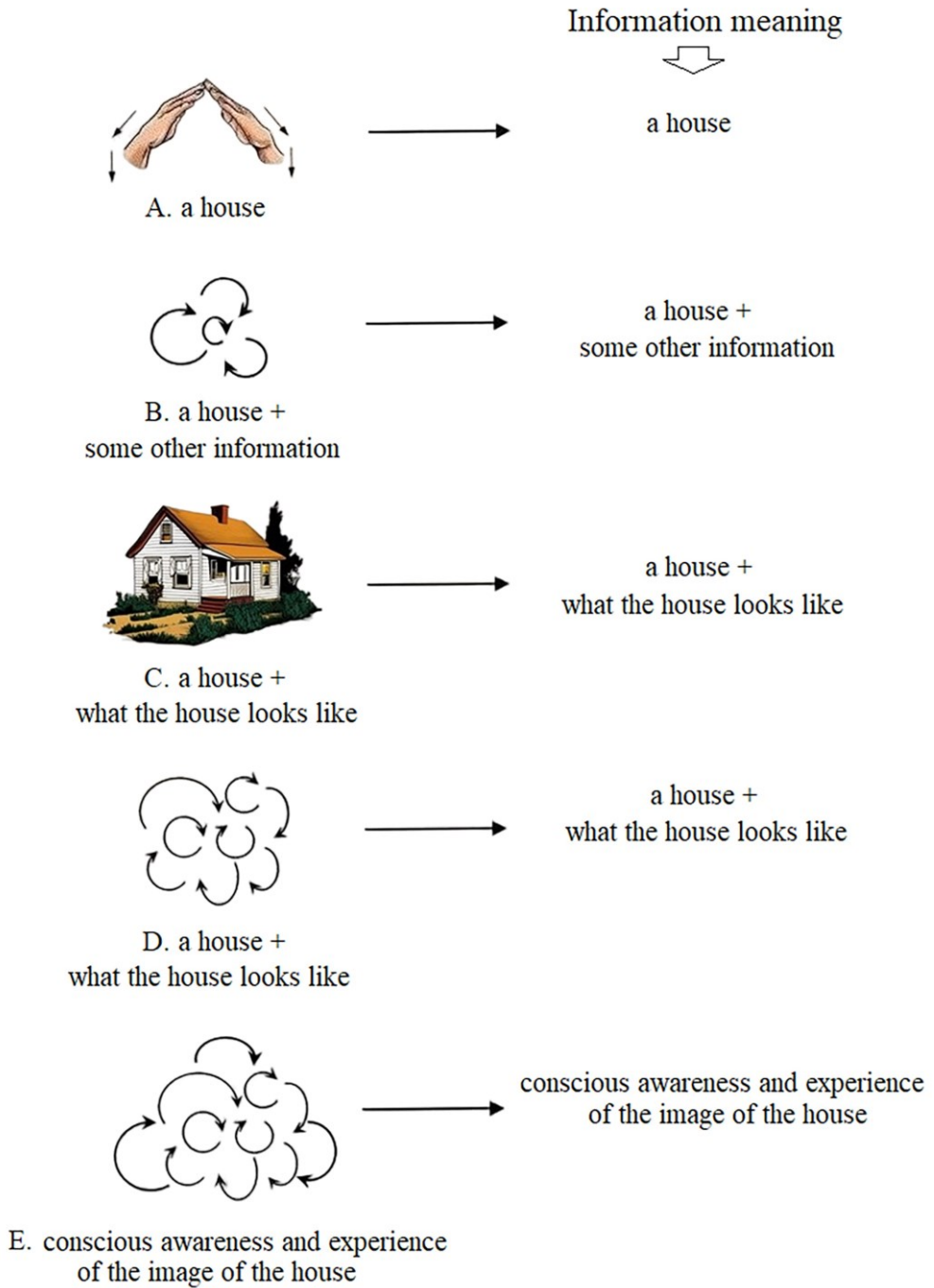


Figure 8.1 Various signals with different information meanings

Next, consider Figure 8.1C. The information of the signal means “a house” and “what the house looks like” to those who can interpret this image, such as healthy adults. When they read this signal, they will get the information meaning both “a house” and “what the house looks like” from the signal; they will not get information meaning “a house” alone. Other receivers who cannot understand the image or, equivalently speaking, those to whom the signal does not mean “a house” and “what the house looks like,” such as babies or non-human animals, will not get the information meaning “a house and what the house looks like” from the signal but will get something else, such as something colorful but meaningless to them.

Similarly, consider Figure 8.1D, which depicts a signaling pattern of a certain conscious neural process, such as some conscious visual perception neural process. The information of the signal means “a house” and “what the house looks like” to some receiving neural processes, such as the consciousness neural process. When these neural processes read the signal, they will get the information meaning both “a house” and “what the house looks like” from the signal, and the signal will be interpreted as such by these neural processes. Consequently, “a house” with “what the house looks like” will naturally and inevitably appear in them—that is, the image quale of the house, which manifests what itself looks like, will and must appear in these receivers. If the receiver is the consciousness neural process, because of the available information (about what the house looks like) and its specialized ability, the signaling state, as depicted in Figure 8.1E, that has the information that means “awareness and an experience of what the house looks like” to the consciousness neural process itself can be generated. When the consciousness neural process reads this signaling state via reentrant signaling, it will be interpreted as such, and “awareness and an experience of what the house looks like” or consciousness of the house image will naturally and inevitably appear in it.

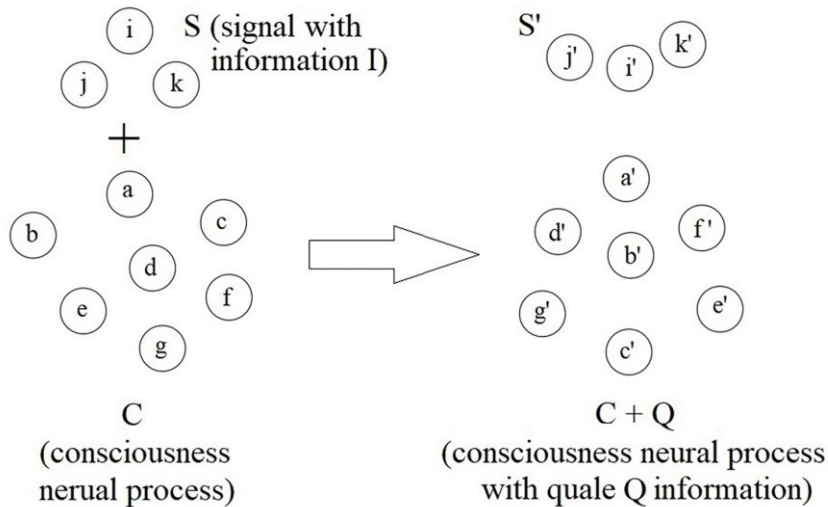
On the other hand, other receivers that cannot understand the signal in Figure 8.1D or, equivalently speaking, those to which the signal does not mean “a house” and “what the house looks like,” such as unrelated neural processes or computers (if the signal could somehow be fed to them), will not get the information meaning “a house” and “what the house looks like” from the signal. Consequently, the image of the house with the manifestation of what the house looks like or the image quale of the house will not and cannot occur in them. Similarly, awareness and an experience of what the house looks like or consciousness of the house image, which require prior information about “what the house looks like,” will not and cannot, either.

Thus, it can be seen from the above examples that various signal receivers can interpret the same signals differently, or, equivalently speaking, the same signals can have different meanings to different receivers. In general, the meaning of a signal depends on the signal information, the readers, and the context of the signal reading (which is not discussed in the examples above because it is the same for receivers in each example).

Therefore, when the signal and the context of signal reading are the same, the meaning of the information in the signal depends only on the receivers. Hence, in the case of qualia (Figure 8.1D), although the signal's information does not mean a quale to most receivers, it can have such a meaning to some (such as the consciousness neural process), and a quale (such as an image of a house) will appear in them.

8.1.2 What is the mechanism for a physical signal to mean a quale?

In the previous subsection, it has been shown that some signals can mean a quale to some receivers. However, what is the mechanism for a physical signal to mean a quale, such as a mental image of a house, to a receiver? The answer is that, for a signal to mean a quale to a receiver, the signal must have physical effects on the receiver such that the quale becomes information in the receiver's processing system. For example, please see Figure 8.2. If Signal S with information I meaning Quale Q (such as a mental image of a house) to the consciousness neural process C, it must have the effects on C such that physical interactions occur as follows: S (I) interacts with C → a cascade of physical interactions occurs in C → components in C change → Quale Q becomes information in C.



S = a signal with information I that means quale Q to C
S' = the signal after the information transfer
C = the consciousness neural process before reading S
C + Q = the consciousness neural process after reading S
Q = a quale (such as an image of a house)

Figure 8.2 The mechanism for a signal and information to mean a quale

That Quale Q has become information in C can be evidenced by subsequent C's activities, which will reflect that C has this information. For example, C can be aware of and experience Quale Q and send Quale Q's information to other processes, resulting in other processes being able to think about Quale Q, have emotions concerning Quale Q, remember and recall Quale Q, and report Quale Q to the outside world—all of which were not possible for C before reading (interacting with) Signal S.

In detail, this means that, if $C + Q$ (or the consciousness neural process C with quale Q in its system) is composed of elementary particles $[a', b', c', d', e', f', g']$ with specified characteristics—spatial position, velocity, mass/energy, electrical charge, and spin—for $[a'] = a'_1, a'_2, a'_3, a'_4, a'_5$, respectively, for $[b'] = b'_1, b'_2, b'_3, b'_4, b'_5$, respectively, and so on, and if C, or the initial consciousness neural process that does not have Q in its system, is composed of particles $[a, b, c, d, e, f, g]$ with the same specified characteristics for $[a] = a_1, a_2, a_3, a_4, a_5$, $[b] = b_1, b_2, b_3, b_4, b_5$, and so on, then, for information I in the signaling pattern S to mean Q to the receiver C, S's particles $[i, j, k]$ must interact with C's particles $[a, b, c, d, e, f, g]$ such that a physical interaction cascade occurs in C that ultimately changes C to $C + Q$, that is, changes $[a]:(a_1, a_2, a_3, a_4, a_5)$ to $[a']:(a'_1, a'_2, a'_3, a'_4, a'_5)$, $[b]:(b_1, b_2, b_3, b_4, b_5)$ to $[b']:(b'_1, b'_2, b'_3, b'_4, b'_5)$, and so on.

Although, at present, we do not know the characteristics of a signal S that can have information I with such physical effects, it is certain from real-life evidence that S and I exist, because some neural signals evidently have information that means qualia to the consciousness neural process C and can change C to $C + Q$. That is, the state $C + Q$ does exist—we can become aware of and experience what Q is like, think about Q, have emotions concerning Q, remember and recall Q, report Q to the outside world, and so on.

The crucial question is how is it possible that a signaling pattern having information meaning a quale (such as the signaling pattern in Figure 8.1D) and a signaling state having information meaning awareness and an experience of what the quale is like (such as the signaling state in Figure 8.1E) to some receivers can be created? The answer is that it must be basically possible for such a signaling pattern and signaling state to be created because qualia and awareness and experiences of what qualia are like do occur in billions of humans everywhere, nowadays and in the past. Also, some neural processes (such as the visual perception neural processes) must basically be able to create such signaling patterns, and some other neural processes (such as the consciousness neural process) must basically be able to create such signaling states. Otherwise, these phenomenal phenomena—qualia and consciousness—would not have been occurring in human brains since the ancient past and up to the present time. It is a brute fact.

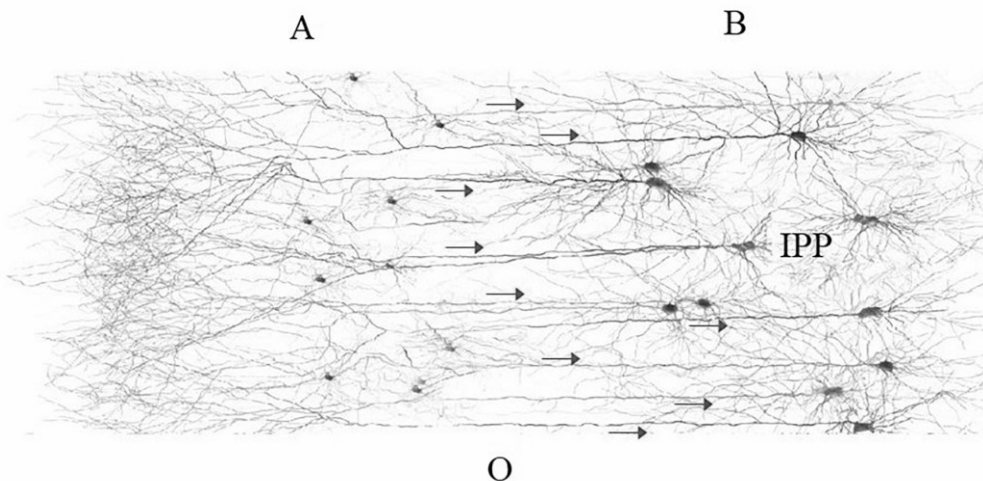
If we consider this matter in general, it is not very surprising or improbable that these phenomena happen. Ever since the nervous system appeared in this world hundreds of millions of years ago, there have been innumerable kinds of neural processes with myriad

kinds of signaling patterns and signaling states that carry diverse kinds of information for various kinds of neural functions: processing different sensory signals, keeping numerous blood constituents within normal ranges, controlling vascular and cardiopulmonary functions, performing diverse cognitive operations, controlling volitional movements, and so on. All these functions require evolved specific neural processes with specific signaling patterns and specific signaling states that have specific information of their own. The quale neural processes are just evolved neural processes with their own specific functions—creating signaling patterns that have information that means qualia or phenomena manifesting what they are like, such as an image of a house, a sound of a song, and an odor of a flower, to their receiving neural process, the consciousness neural process. And the consciousness neural process is just one evolved neural process with its own specific function—creating signaling states that have information that means, to itself, awareness and experiences of what qualia are like, such as awareness and an experience of what an image of a house, what a sound of a song, and what an odor of a flower are like. To repeat, it is just the fundamental nature of this universe that these neural processes, signaling patterns, and signaling states exist.

8.2 The Point-of-View Approach

8.2.1 How can a signaling pattern be a quale?

First, please look at the signaling between neural circuits A and B in Figure 8.3.



*A = neural circuit A, B = neural circuit B, IPP = information-processing process,
O = outside observer, small arrows = the signals that A is sending to B*

Figure 8.3 Signals in the view of an outside observer O

From the point of view of an outside observer (O), who observes the brain from the outside, or from the third-person point of view, what appears to occur is that innumerable electrical signals (small arrows) in the form of APs (action potentials) are sent from neurons in one circuit (A) to neurons in the other circuit (B) incessantly and that EPSPs or IPSPs (excitatory or inhibitory postsynaptic potentials) occur almost continuously at the synaptic junctions here and there in B. In this view, those electrical signals and the resulting signaling pattern do not appear to be or be able to be a quale (i.e., an image, sound, emotion, thought, or any other quale, which manifests what itself is like in our minds); they are just phenomenonon-less (i.e., phenomenality-less) electrical signals and patterns.

However, for the signals to appear as in this view, the observer must observe them (typically by using some instruments) from the outside of the signaling. From this point of view, the information in the signaling pattern is *not read*—it is *only observed* or *looked at*. We will see that this differs from the following case and that the difference is most critical.

From the point of view of the information-processing process (IPP) of neural circuit B that is receiving the signals or from the first-person point of view, the signals appear different because the IPP's point of view and its way of interacting with the signals are different from those of the outside observer (O):

- 1) From its position, the IPP cannot observe the signals from the outside of the signaling because it is part of the signaling—it is the receiver of the signals. Moreover, the world of the IPP is drastically different from that of O:

The IPP does not know that it is a non-material process in a material circuit composed of millions of neurons with innumerable interconnecting axons and dendrites, connected to several other neural circuits, and with countless APs coursing the circuits and a multitude of EPSPs and IPSPs occurring at the synaptic junctions incessantly, as in Figure 8.3. In short, in the world of the IPP, there are no neurons, axons, dendrites, synapses, electrical/electrochemical (E/EC) activities, or other material things. The IPP is oblivious to these material components because there is nothing that detects and reports these things to it; thus, there is no information about them in it. All that exists for the IPP is non-material things that it receives from something outside, processes, and then sends to something outside or circulates in itself. Because this non-material thing is transferred to the IPP from something, is later transferred from it to something, and consists of content that it can process and transfer, this non-material thing is transferable and consists of content—it is thus information (please see I.1 Information: Definition, in Extra Chapter I). That is, information, information processing, and information transfer are all there is in the world of IPPs. The world of the IPP can be depicted as the illustration in Figure 8.4, not the one in Figure 8.3, which is not the world of an IPP but that of an outside observer O.

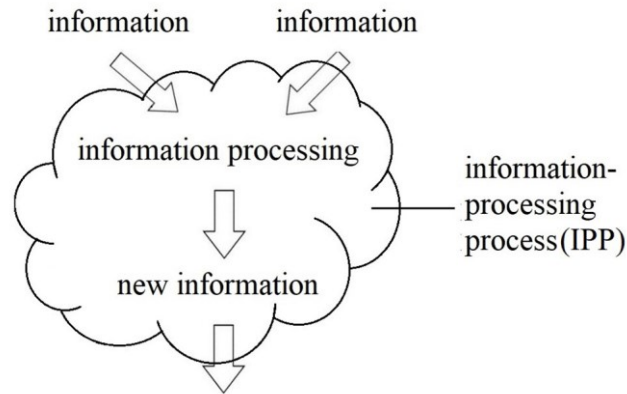


Figure 8.4 The world of an information-processing process (IPP)

2) Now, when the signals interact with the IPP (as in Figure 8.3), the information in the signaling pattern will be read and processed by the IPP (as in Figure 8.4). How the signaling pattern appears to the IPP depends solely on the information in the signaling pattern. For example, if the information means a blood sodium level of 135 mEq/L without phenomenality to the IPP, a phenomenonon-less blood sodium level will appear in the IPP (represented by L in Figure 8.5). On the other hand, if the information means red with phenomenality (red with a manifestation of what the red is like) to the IPP, a phenomenal red quale will appear in the IPP (depicted as a red disc in Figure 8.5).

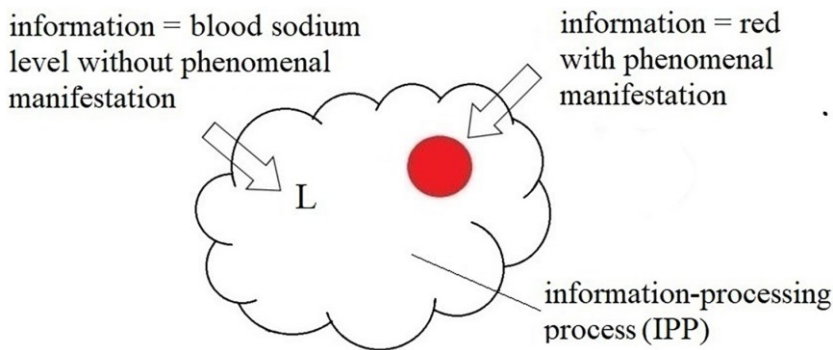


Figure 8.5 Appearances of different types of information in the IPP

This is how a quale occurs in an IPP: *The information that means a quale to an IPP is read and interpreted as such by the IPP (which has the first-person point of view).* When that happens, the information naturally and inevitably appears as the quale—a quale thus appears in an IPP ... and the physical brain.

If the receiver is the consciousness neural process, we can assess whether the signaling pattern or information appears to it as a quale by checking the reports of how the signaling pattern appears to it that it sends to other neural processes. Some of these neural processes can reveal those reports to the outside world by verbal, written, or other types of language. Because these neural processes function to report to other neural processes factually, if they reveal that the consciousness neural process reports to them that the signaling pattern appears as a quale, the signals must appear as a quale to the consciousness neural process; otherwise, the signals must appear as something that is not a quale to the consciousness neural process.

This kind of qualia appearance from neural signals is verifiable in everyday life. For example, if we look at the brain of a person who is looking at a red color, we will not see anything red occurring in his or her brain. However, we can check how the neural signals of the red color, which are in the form of signaling patterns in the brain, appear to the IPP of his or her consciousness neural process by asking the person. A visually healthy and cooperative person will report (by verbal, written, or other types of language) that he or she sees and experiences what the red color is like in his or her mind. Such a report means that the neural processes that reveal this event (through the means of speaking, writing, or other signaling) have received accounts from the IPP of the consciousness neural process that the signaling pattern of the red-color perception appears as a red color that manifests what the red color itself is like to it. Therefore, signaling patterns, which are phenomenon-less when observed or looked at from the outside or third-person point of view, can indeed appear as phenomenal qualia to the IPP of the consciousness neural circuit that is reading the signaling patterns from the first-person point of view.

An approximate analogy is the working of a cathode-ray tube. Please see Figure 8.6.

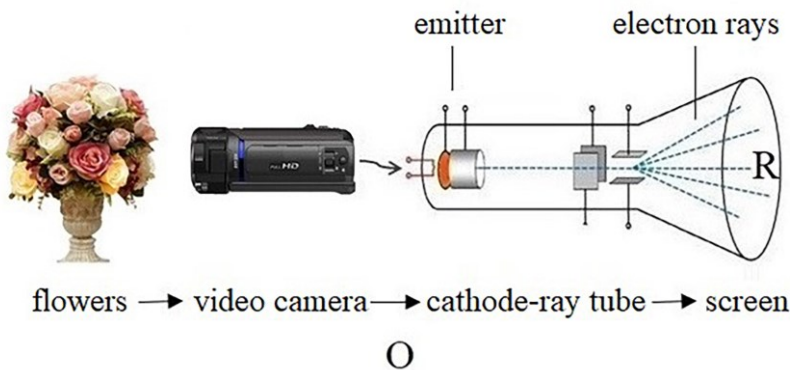


Figure 8.6 A cathode-ray tube analogy

The rays of electrons streaming out of a cathode-ray tube emitter in some signaling pattern representing a beautiful flower bouquet do not seem to be any colorful flower (or

any image at all) to an outside observer (O) who is observing the streams from the outside. To O, they are just millions of electrons rushing from the emitter to the screen, and the pattern of signaling does not seem to be anything close to an image of a flower bouquet either. On the other hand, from the point of view of the receiver (R) of the electron rays, if R is the appropriate kind of screen that can correctly interact with the electron rays and thus can correctly interpret (decode) the information in them, the image of the beautiful flowers sent in the electron rays will appear on it. Therefore, image-less electron rays in the third-person point of view can become a colorful image in the first-person point of view.

At this point, it is essential to emphasize that, for the flower bouquet image sent in the signals to occur at the screen, the screen must be a specific one that can correctly interact with and decode the signals; otherwise, the signals will appear as something else or even nothing on the screen. Semantically speaking, the screen must be a specific one to which the information in the electron rays means an image of a flower bouquet. Not every screen can be such a screen.

This is the same in the case of neural signaling. Even if we can obtain the signals that neural circuit A sends to neural circuit B in Figure 8.3 and feed them to another neural circuit, a computer, or other signal-analyzing systems, these receivers cannot interact with the signals in the way that the IPP of neural circuit B can and thus cannot decode the information in the signals. Therefore, the effects of the signals on such receivers will differ from those on the IPP, and the signals will appear differently to these receivers than to the IPP. Semantically speaking, the information in the signals does not mean the same thing to these receivers as it does to the IPP. For example, if neural circuit A is the final visual perception circuit and the signals being sent mean the colorful-flowers image to the IPP of the consciousness neural circuit, then the colorful-flowers image will appear in this IPP, although it will not do so in other receivers.

It should be noted that this kind of explanation involving the first- and third-person points of view and different ways of observation has been discussed before by several authors, such as *Globus (1973)* [20], *Velmans (1996,2001,2002,2009)* [18,21–25], *Feinberg (2012)* [26], *Feinberg and Mallatt (2016,2020)* [10,11], and *Solms and Friston (2018)* [27]. *Feinberg (2012)* [26] and *Feinberg and Mallatt (2016)* [11] called the barriers that prevent the first person from having the third-person point of view “auto-ontological irreducibility” and those that prevent the third person from having the first-person point of view “allo-ontological irreducibility.” *Solms and Friston (2018)* [27] called the first- and the third-person points of view subjective perspective or interoceptive and objective perspective or exteroceptive, respectively. *The dual-aspect theory*, for example, suggests that a conscious experience and its correlated brain state are how the mind appears when viewed from first- and third-person perspectives, respectively, and that these aspects of the mind are complementary and mutually irreducible [18].

However, although these authors gave convincing arguments that the different points of view are responsible for different depictions of the same information, they did not give a rationale as to why something with phenomenality—qualia and consciousness—should appear in the first-person point of view. On the other hand, this theory offers a principle of why phenomenality should appear in the first-person point of view: The interpretation of information's meaning, which can occur only in the first-person point of view, enables information that means something with phenomenality—qualia and consciousness—to the receiver to appear as such in the receiver.

Summarily, when viewed from the third-person point of view, signals appear as a complex composition of physical, phenomenon-less signals because they are *observed* but *not read*; consequently, their information is not interpreted and hence does not display itself. In contrast, when read from the first-person point of view, the signals appear to be something that their information means because they are *not observed* but *read*, so the information in them is interpreted and displays itself to the receiver. Thus, if a signal, such as a special signaling pattern, has information that means a quale to the receiver, it will naturally and inevitably appear to the receiver as the quale. Furthermore, if the receiver is the consciousness neural process, conscious awareness and experience of the quale will be subsequently created from the quale that has appeared in it. Fundamentally, there is no physical law that a) restricts information from meaning qualia, b) forbids information that means a quale to a receiver from appearing as the quale to the receiver, and c) precludes occurrences of qualia, which are non-material phenomena, in the non-material world of the information-processing process (as depicted in Figures 8.4 and 8.5), and thus in the mind and the brain, in which the information-processing process exists.

*Every time you wonder
how material physical signals can be qualia,
remember to move from the third-person point of view
to the first-person one,
and change from looking at the signals
to reading and processing their information.
The beautiful flowers will appear in your view.*

8.2.2 How can a signal state be consciousness?

The way to answer this question is the same as that in the case of a signaling pattern. Accordingly, the explanation will proceed similarly but with some modifications to suit the case of consciousness, which is a signaling state (specifically, a reentrant signaling state), unlike a quale, which is a signaling pattern.

Please look at the signaling state of the conscious neural process in Figure 8.7.



(looping curved arrows = a reentrant signaling state)

Figure 8.7 The signaling state in the view of an outsider

From the point of view of an outsider who looks at the brain from the outside or the third-person point of view, what appears to occur is that innumerable electrical signals (curved arrows) in the form of APs are being circulated from one neuron to another incessantly and that EPSPs or IPSPs occur almost continuously at synaptic junctions here and there in the reentrant neural circuit. In this view, the electrical signals and the signaling state that occurs do not appear to be or be able to be anything that has phenomenal manifestations; they are just phenomenon-less electrical signals circulating in some pattern, resulting in a certain signaling state.

However, for the signals to appear as in this view, the observer must observe the signals (by using some instruments, in general cases) from outside the signaling. And it is essential to note that, in this view, the information that is circulating in the signaling state is *not read*—it is *only observed* or *looked at*. We will see that this differs from the following case and that the difference is most critical.

Next, let us examine the situation from the point of view of the information-processing process (IPP) in a reentrant neural circuit (such as the consciousness neural circuit, in which the signaling state occurs) or the first-person point of view (Figure 8.8):

1) From its position, the IPP cannot observe the signals from the outside of the signaling because it is part of the signaling—it is both the sender and the receiver of the signals. Moreover, the world of the IPP is drastically different from that of an outside

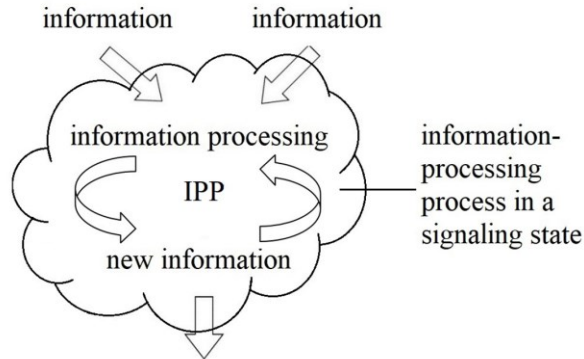


Figure 8.8 The world of the IPP of a signaling state

observer. Similar to the case of a signaling pattern, there are no neurons, axons, dendrites, synapses, E/EC activities, or other material things in the world of the IPP; only information, information processing, and information transfer exist in it. The world of the IPP can be depicted as the illustration in Figure 8.8, not those in Figures 8.3 and 8.7.

Additionally, even though all the somas, axons, dendrites, and synaptic junctions of millions of neurons in the neural circuit are separated and thus spatially discontinuous, the IPP does not see the information coming into it or existing in it in a discontinuous pattern. This is because there is nothing that detects and reports these discontinuities to it; consequently, there is no information about them in it. Thus, in the world of the IPP, gaps do not exist, and there is only *a continuous expanse of information, information processing, and information transfer*. It should be noted here that, similarly, there are no gaps between various kinds of perception (visual, auditory, olfactory, etc.), emotions, thoughts, and other mental phenomena in our minds.

2) Now, when the signals that are circulating in the reentrant neural circuit (Figure 8.7) are read by the IPP, the information in the signaling state will be processed and interpreted by the IPP (Figure 8.8). How the signaling state appears to the IPP depends solely on the information in the signaling state. If the information means consciousness of a quale (i.e., conscious awareness and experience of a quale or awareness and an experience of what the quale is like) to the IPP, it will be interpreted as such, and consciousness of the quale will naturally and inevitably occur in the IPP.

We can determine whether the signaling state of the consciousness neural process appears to its IPP as consciousness by checking the consciousness neural process's reports (of how the signaling state appears to it) that are sent to other neural processes. Some of these neural processes can reveal those reports to the outside world by verbal, written, or other types of language. Because these neural processes function to report to each other and the outside world factually, if they reveal that the consciousness neural

process reports to them that the signaling state appears as consciousness, the signaling state must certainly appear as consciousness to the IPP of the consciousness neural process, and consciousness must really have appeared in the IPP of the consciousness neural process.

Indeed, such is the case in everyday life. For example, in the case of someone looking at a red color, we can assess how the signaling state of the consciousness neural process appears to the consciousness neural process itself by asking the person who is looking at the red color. A visually healthy and cooperative person will report (by verbal, written, or other types of language) that he or she sees a red color quale and is aware of and experiences what the red color quale is like in his or her mind. Such a report means that the neural processes that reveal this event (by speaking, writing, or other signaling) have received accounts from the consciousness neural process that the signaling state resulting from looking at the red color appears to its IPP as consciousness, or conscious awareness and experience, of the red color quale (Figure 8.9).

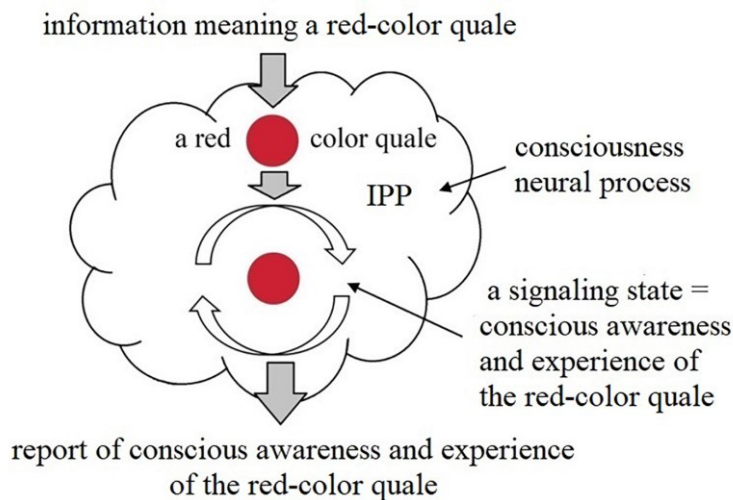


Figure 8.9 Appearance of a red color quale and the consciousness of it in the IPP

Therefore, when observed from the outside, the consciousness neural process's signaling state of seeing a red color naturally appears phenomenon-less to the observer because it is not read and interpreted. On the other hand, when read from the inside, it must appear as phenomenal consciousness of a red color quale to the consciousness neural process's IPP because it is read and interpreted.

To summarize, similar to the case of qualia, when viewed from the third-person point of view, signals appear as a complex composition of physical, phenomenon-less signals because they are *observed* but *not read*; hence, the information in them is not interpreted

and thus cannot display itself. Contrastingly, when read from the first-person point of view, the signals appear to be something that their information means because they are not *observed* but *read*, so the information in them is interpreted by the reader and displays itself to it. Thus, if a signal, such as a special signaling state, has the information that means conscious awareness and experiences, or consciousness, to the consciousness neural process, it will naturally and inevitably appear to the consciousness neural process as consciousness. And consciousness will and must occur in the brain. Fundamentally, there is no physical law that a) restricts information from meaning consciousness, b) forbids information that means consciousness to a receiver from appearing as consciousness to the receiver, and c) precludes occurrences of consciousness, which is a non-material phenomenon, in the non-material world of the information-processing process (as depicted in Figures 8.8 and 8.9), and thus in the mind and the brain, in which the information-processing process exists.

8.3 Remarks

The explanatory gap has been an essential problem in philosophy and cognitive neuroscience for a long time. There have been many discussions about it, and numerous concepts and theories have been proposed to solve it; for example, please see References 1–19, 28–30. However, the issue has been unsettled.

If this problem is examined critically, it can be seen that it originated from the assumption that non-phenomenal physical entities, such as the brain, are the basic entities, primarily present, and that phenomenal entities, such as qualia and consciousness, arise from or are caused by the former entities later. Thus, there is a need to explain how that can happen. But there are no physical laws that underlie and govern a causal link between the physical and phenomenal entities. Hence, the explanatory gap arises and persists.

However, the assumption has no empirical basis. It is possible that both types of entities have always coexisted since their beginnings. Thus, there is no need to explain how one type can arise from or cause the other, and the explanatory gap never exists. The question is: If this is the case, what are the entities that always exist with the brain and are qualia and consciousness? According to this possibility, they must already coexist with the brain; it is only that we do not recognize them.

Once we identify that qualia and consciousness are patterns in the forms of signaling patterns and signaling states, respectively, everything falls into place. Patterns with their information have naturally existed with physical entities since the universe's inception (please see I.3 The Nature of Information, Extra Chapter I). At a certain evolutionary stage, some of them evolved into SSSs and SSPs, which were qualia and consciousness, respectively. Because SSSs and SSPs are evolved forms of previously existing entities—patterns—not emerging new entities, no explanation is needed for the presumed

emergence of qualia and consciousness. Also, from the third-person point of view, our usual point of view when we think about or investigate patterns and information in labs, they do not appear phenomenally as they do when viewed or, to be exact, read from the first-person point of view, the natural point of view of functioning neural processes. This is because the information in the patterns is not read and interpreted in the former case but is in the latter case.

Thus, the explanatory gap of how qualia and consciousness can occur in a physical system can be explained by existing scientific knowledge about physical patterns and information, specifically information meaning and interpretation, about their evolution, and about the observer's point of view or the way the observer interacts with information.

The explanatory gap is part of the hard problem of qualia and consciousness—the “how” part. It will be revisited with the “why” part and other related problems of the hard problem in the next chapter, which offers full discussions with various perspectives of the problem.



Figure 8.10 WE

*Once more, every time you wonder how material signals
can give rise to qualia and consciousness,
remember to move into the world of information processing
and experience everything from there.*

*You will be in the dazzling world of qualia
and the experiential world of consciousness.*

...

*That world always exists
side by side with the outside physical world
since the birth of everything.*

WE live there.

Chapter 9

The Hard Problem of Qualia and Consciousness

The problems related to qualia and consciousness are among the most crucial puzzles of our lives, both from scientific and spiritual perspectives. They can be categorized into two major types. One concerns the physical machinery necessary and sufficient for their occurrence and functions, while the other is about why and how they occur in a physical system. The former is called the easy problem because, at least theoretically, it is possible to find answers. The latter is known as the hard problem [1–19] because, even in theory, no scientific knowledge seemingly exists to provide a solution. Some even believe this problem is inherently unsolvable, a belief known as Mysterianism [4,12,19,20].

The way to find the answers to the easy problem is straightforward. Basically, it is a matching process: by scientific methods, pairing occurrences and functions of qualia and consciousness with certain neural circuits and processes. Expectedly, this can be done with current or near-future technology. However, although named the easy problem, practically, it is one of the hardest scientific endeavors of mankind. Yet, again, the answers are theoretically achievable. On the other hand, existing theories and knowledge seem unable to explain how phenomenal qualia and consciousness can occur from phenomenon-less (phenomenality-less) physical systems and why they should occur at all. Even if we finally know the exact neural circuits and processes for qualia and consciousness, there is no prospect that we can answer these problems. Essentially, it seems to be the problem of our current fundamental theories of physics being unable to explain why and how something with phenomenality, such as qualia and consciousness, can and should occur from the elementary particles and their interactions. Thus, the problem is hard.

Nevertheless, the real root of this conundrum may not be the incompleteness of the fundamental physical theories but our lack of understanding of the physical nature of qualia and consciousness. Naturally, we cannot answer with existing theories why and how qualia and consciousness occur in physical systems if we do not know what they physically are. Physical laws apply only to physical entities. Without knowing their physical nature—what kinds of physical entities they are—no physical laws can ever be used to account for their occurrences. Theoretically, once we can ascertain what they are physically from empirical investigations, we will be able to resolve, based on existing physical theories, their problems, including how and why they occur, causing the puzzles to disappear. Therefore, if we seek parsimony, not adding physical laws unnecessarily, we must first strive to find their physical nature, which has not been established before. Only if this endeavor fails, will it be necessary to institute new physical rules.

Based on the physical properties of qualia and consciousness and on current scientific evidence, this theory has solved the problems of what qualia and consciousness are physically and ontologically, as carried out in Chapters 3 to 7, and the results are stated as Theorems IV and V. These theorems provide scientifically verifiable predictions. Up to the present time, they have not been invalidated by clinical or experimental findings and are thus sound. These sound, evidence-based theorems provide rational answers to the above and other related problems as follows:

9.1 The Essence of the Problem

9.1.1 What are qualia and consciousness?

Qualia: Physically and ontologically, qualia are signaling patterns of some neural processes (Theorem IV). Specifically, they are special signaling patterns (SSPs), which are a special type of signaling pattern with information that means qualia—mental phenomena that manifest what themselves are like, such as an image of a house, a sound of a song, and an odor of a flower—to the consciousness neural process. Therefore, when some neural processes produce SSPs and the consciousness neural process reads them, it interprets them as qualia, and qualia naturally and inevitably appear in the consciousness neural process, and thus in the brain. This is how qualia occur in the physical brain.

Consciousness: Physically and ontologically, consciousness is the signaling state of the consciousness neural process (Theorem V). Specifically, it is a composite of special signaling states (SSSs), which are signaling states of a special type with information that means consciousness—awareness and experiences of what qualia are like, such as awareness and experiences of what an image of a house, what a sound of a song, and what an odor of a flower are like—to the consciousness neural process itself. Therefore, when the consciousness neural process produces a composite of SSSs and then reads it through reentrant signaling, it interprets it as consciousness, and consciousness naturally and inevitably appears in the consciousness neural process, and thus in the brain. This is how consciousness occurs in the physical brain.

Qualia and consciousness: It is essential to note that SSPs themselves are qualia and that SSSs themselves are consciousness. Because signaling patterns and signaling states are inherent in the neural processes, so are qualia and consciousness. Thus, no new entities emerge or are created from physical, neural processes to be qualia and consciousness. It is only that some signaling patterns do not mean qualia (but mean something else), while SSPs do, and that some signaling states do not mean consciousness (but mean something else), whereas SSSs do, that makes it seem as if qualia and consciousness emerge as novel entities in the brain. For example, when we are asleep, under generalized anesthesia, or in a coma, no neural processes produce SSPs or SSSs, and the signaling patterns and signaling states in these conditions mean something else, which is not qualia or consciousness; consequently, there are no qualia and

consciousness in such conditions. However, when we wake up or recover from anesthesia or coma, qualia-producing neural processes *change* from producing signaling patterns that are not SSPs to producing those that are, and the consciousness neural process, from producing signaling states that are not SSSs to producing those that are. Accordingly, the meanings of the signaling patterns' information *change* from not-qualia to qualia, and those of the signaling state's information, from not-consciousness to consciousness. As a result, qualia and consciousness occur. Evidently, qualia and consciousness are not some new entities that emerge in the brain in these conditions but are simply *changed* signaling patterns and *changed* signaling states with *changed* information and *changed* meanings. The seeming emergence of qualia and consciousness is actually *changes* of signaling patterns and signaling states, together with changes of their information and meanings.

Therefore, when there are no SSPs or SSSs, there are neither qualia nor consciousness. Thus, ***qualia and consciousness do not always exist***. These facts have always been true since the beginning of the universe. In the distant past, in the primordial era of the universe when there was no life and in the early period of evolution when there was life but the nervous system had not evolved to exist yet, there were neither SSPs nor SSSs. Even at present, SSPs and SSSs do not exist in entities that are not animals with a nervous system. Furthermore, in animals with a nervous system, SSPs and SSSs do not occur in a variety of conditions and diseases, such as those exemplified in the previous paragraph, and in the early fetal period, when the nervous system has not developed yet. Therefore, there were no qualia and consciousness in the distant past, and there are none in many entities at present.

Nevertheless, even though qualia and consciousness—or, equivalently, SSPs and SSSs—did not exist in the distant past and do not exist in many entities at present, patterns and information have always been present in physical entities. This is because, since the universe's inception, all physical entities have always possessed patterns—specifically, patterns composed of their physical characteristics (please see Section I.4, Extra Chapter I: Information). For example, whether it is a living cell, an inert rock, or a molecule, each entity has a distinctive pattern formed from the physical attributes—spatial position, velocity, mass/energy, electrical charge, spin, etc.—of its constituents. This holds true even at the level of a single elementary particle, which also possesses a discernible pattern composed of its fundamental physical traits—spatial position, velocity, mass/energy, electrical charge, spin, etc. [21–24]. Further, because patterns are information (please see Section I.4, Extra Chapter I: Information), information always exists in all physical entities. Thus, both patterns and information are inherent in all physical entities. Again, this has been true since the origin of everything.

The crucial point is evolution. Patterns and information, similar to everything else, evolve. Primitive physical patterns evolved into more complex physical patterns, then biological patterns, then neural patterns, and finally special kinds of neural patterns, the

SSPs and SSSs, which have information that means qualia and consciousness, respectively, to the consciousness neural process, without any new entity emerging to be qualia and consciousness.

This explains the hard problem of how phenomenal qualia and consciousness emerge in physical systems. Really, qualia and consciousness are not novel entities and do not emerge from anything; they are evolved forms of the ever-present basic entities—patterns and information—which have always existed inherently in the physical systems since their beginning.

9.1.2 How can patterns and information, which do not seem to have phenomenality, be phenomenal qualia and consciousness?

This problem is answered in the preceding chapter, The Explanatory Gap. Briefly, patterns and information that mean phenomenal qualia and consciousness do not display phenomenality when they are observed from the third-person point of view, which is the point of view we usually have when we think about them or examine them in laboratories. However, when they are read, not merely observed, from the first-person point of view, which is the natural point of view of the consciousness neural process, they naturally and inevitably appear as phenomenal qualia and consciousness to the consciousness neural process. The discrepancy in their manifestations occurs because, when they are observed from the third-person point of view, their information meanings are not interpreted and thus cannot and do not reveal themselves; by contrast, when read from the first-person point of view, their information meanings are interpreted and thus can and do reveal themselves.

9.1.3 Why do qualia and consciousness exist?

Qualia and consciousness exist in this universe because it is fundamental to the nature of this universe that they exist. And they exist in the nervous system—in the SSPs and SSSs—because, in this universe, it is fundamental to the nature of neural signaling patterns and signaling states that some of them are qualia and consciousness. To the consciousness neural process, some types of neural signaling patterns, the SSPs, mean mental phenomena that manifest what themselves are like or qualia, and some types of neural signaling states, the SSSs, mean awareness and experiences of what qualia are like or consciousness. This is a brute fact.

9.1.4 Why did qualia and consciousness occur, and why do they still occur?

At first, qualia and consciousness occurred because, at some evolutionary stage about 520 million years ago, it was possible for the nervous system, which was advanced enough then, to evolve new kinds of neural processes that could produce SSPs, which were qualia, and SSSs, which were consciousness. Thus, qualia and consciousness occurred at some time in the past simply because the nervous system was advanced

enough then and because, given time and appropriate conditions, certain variations eventually occur.¹⁸

At present, qualia and consciousness still occur because there still are some kinds of neural processes producing them. Evidently, that these kinds of neural processes have endured since their inception signifies that they have been preserved in the evolutionary process. This, in turn, indicates that they and their products—qualia and consciousness—must yield some effects that help increase the survival chances of the species that possess them. Thus, qualia and consciousness still occur today because they must somehow help increase the survival chances of the species that possess them [32–47].

9.1.5 When do qualia and consciousness occur?

First, as discussed in 9.1.4, qualia and consciousness began to occur in this world around 520 million years ago. After that, qualia and consciousness occurred whenever neural processes produced SSPs and SSSs. It is important to note that it is impossible for qualia and consciousness to not occur when neural processes produce these signals, because these signals themselves are qualia and consciousness.

9.1.6 How do qualia and consciousness occur?

Qualia and consciousness occur by the functioning of neural processes. Specifically, they occur by neural processes producing SSSs and SSPs, respectively. The SSPs themselves are qualia, and the SSSs themselves, consciousness—no additional entities emerge or are created to be qualia and consciousness.

9.1.7 How do we know that qualia and consciousness did not occur in some primitive animals before the time asserted in 9.1.4, and is it possible that there are qualia and consciousness in some primitive or less advanced animals today?

Qualia and consciousness as we know them are defined as mental phenomena that manifest what themselves are like and awareness and experiences of what qualia are like, respectively. These complex phenomena require two complex neural structures: one for qualia and the other for consciousness. We have learned from various neuroscientific studies and experiments that such neural structures are exclusively located in the latest evolved parts of the brain—the neocortices of the brain (see neural correlates of

¹⁸ Life began approximately 3.5 billion years ago [25], and primitive nervous systems arose in coelenterates (Cnidaria and Ctenophora) about 700–650 million years ago (mya) [25–27]. Then, more complex nervous systems evolved in primitive deuterostomes 635–540 mya [28] and even more complex nervous systems evolved in primitive vertebrates 560–520 mya [29]. Between 550 and 525 mya, the first fossils of many animal innovations, including eyes, appeared [29–31], and a nervous system complex enough to generate qualia and consciousness arose around 520 mya (in primitive vertebrates) [11,29].

consciousness in Section 6.6). When these cortical areas function, qualia and consciousness occur; when they change their functions, qualia and consciousness change their manifestations; when they stop functioning, qualia and consciousness disappear. Thus, qualia and consciousness as we know them never occur without functions of these areas. Therefore, qualia and consciousness as we know them must have occurred in this world only when these neural structures had evolved to exist and function in the brain, which was around the time estimated in 9.1.4.

It is highly unlikely that qualia and consciousness as we know and define them occurred in primitive animals in the past or exist in present-day primitive animals because these animals did not or do not have advanced-enough neural structures to support occurrences and existence of the two phenomena. However, this question can be definitively answered if we know the exact minimal neural structures that can create qualia and consciousness, which, to date, has not been the case.

9.1.8 Why can there not be just mental processes without qualia and consciousness?

There can be just mental processes without qualia and consciousness, and this had been the case for a long time—hundreds of millions of years—from the moment the nervous system appeared on this planet to the time when evolving neural processes became advanced enough to be able to produce qualia and consciousness. When that time came, qualia and consciousness came into existence simply because it was possible. It is only since that time that mental processes with qualia and consciousness exist. However, it should be noted that, even nowadays, mental processes without qualia and consciousness still far exceed those with them in number—all the sub- or non-conscious mental processes of the cerebral cortex and all the mental processes of the basal ganglia, thalamus, brainstem, cerebellum, and other parts of the nervous system are mental processes without qualia and consciousness.

9.1.9 Do qualia and consciousness have physical effects?

Qualia and consciousness have physical effects, as discussed in Sections 5.3 and 7.3. However, at present, we still do not know what their exact effects are, but the overall effects must be beneficial because qualia and consciousness have been preserved in the evolutionary process.

9.1.9a Why did the nervous system evolve qualia and consciousness to gain beneficial effects; could it not have evolved something else?

It could, and it has done so. In fact, before the nervous system evolved qualia and consciousness, it had been evolving and improving itself by other means since it appeared in primitive animals 700–650 million years ago [25–27]. From a pre-nervous system with scattered neuron-like cells (such as in sponges) to a primitive nerve net (such as in cnidarians), then a primitive nerve cord with primitive nerve ganglia (such as in

flatworms), then a nervous system with a primitive brain (such as in mollusks), then a nervous system with a primitive cerebral cortex (such as in lampreys), and ultimately a nervous system with a more and more developed cerebral cortex (such as in reptiles, birds, mammals, and finally, humans) [25,29,48–59], the nervous system has been evolving to be more complex and more capable throughout time. Even after qualia and consciousness had evolved to exist by evolving new kinds of neural processes with SSPs and SSSs, other parts of the cerebral cortex that functioned without qualia and consciousness in their processes have not stopped evolving. They have been continuing to evolve to be more complex and more capable, resulting in higher intelligence, more language capacity, more manual abilities, etc. [50,52,60].¹⁹ Even the cerebellum and other parts of the brain have proved to continue to co-evolve with the cerebral cortex [50,62] all the time, despite not having qualia and consciousness in any of their neural processes. Thus, ***the nervous system has always been evolving to be more complex and more capable, regardless of the absence or presence of qualia and consciousness.***

The creation of qualia and consciousness is just one possible path in the nervous system's evolution. It remains to be seen whether creating qualia and consciousness is the end of this evolutionary path or whether neural processes with qualia or consciousness can evolve further into new kinds of neural processes with new kinds of mental phenomena that may be even more fascinating than qualia and consciousness. Also, it remains to be seen whether no-qualia and no-consciousness super-intelligences (i.e., super-intelligences without qualia and consciousness) rivaling or exceeding human intelligence (which has qualia and consciousness) can evolve into existence in some animals in the future. Indeed, this kind of development is already progressing rapidly in non-living entities: supercomputers without qualia and consciousness, which are now able to solve many complex mathematical problems that humans can never finish in their lifetimes. They are also able to beat their own creators at complex, intelligent games, such as chess, Go, and bridges [63–67]. Someday, such supercomputers, which do not have qualia and consciousness,²⁰ may become the ultimate entities that are superior to their creators—humans, who have qualia and consciousness—in every way. Regarding animal intelligence without qualia and consciousness, if we consider the powerful capabilities of the cerebellum, which can process billions of signals and control millions of muscle fibers accurately in milliseconds without qualia and consciousness in their processes but can result in such marvelous motor feats as those performed by skillful gymnasts and

¹⁹ *These abilities do not need qualia and consciousness to function, as evidenced by their unconscious function without qualia and consciousness—we know only the results of their functions, but we do neither consciously control nor know how they function [10,61]. Also, they are anatomically and functionally separate from qualia and consciousness. Evidently, they can be interfered with or destroyed without affecting qualia and consciousness.*

²⁰ *This point will be discussed in detail in Section 9.3.1.*

master musicians, it is reasonable to speculate that some animals can possibly develop no-qualia and no-consciousness intelligence and capabilities. Even today, it is possible that some animals that demonstrate intelligence but have quite different brain structures from ours, such as octopuses and bees, may not have qualia and consciousness in their systems.

To enhance its functions, the nervous system has evolved many kinds of neural processes, signaling patterns, and signaling states. The generation of qualia and consciousness is not the necessary or most effective path but merely one possible path for enhancing the nervous system functions.

9.1.9b Why does the nervous system not enhance all mental processes with qualia and consciousness; why does it enhance only some of them?

The cerebral cortex has evolved to be a broadly adaptable system that does not depend on fixed hard wiring of neural circuits alone but can also make use of information processing. However, this system requires an integration center that can coordinate information communications between several cortical modules, most importantly those that function for the final-stage perception of all external sensations and some internal sensations, cognitive perceptions (of space, time, self, non-self, etc.), other cognitive and executive functions (thinking, recalling past events, planning, deciding, language processing, etc.), emotion, and volitional motor control. Such a system can certainly operate without qualia and consciousness, as evidenced by the fact that computers and the cerebellum can also perform these kinds of functions very effectively without qualia and consciousness. However, as shown in Sections 5.3 and 7.3, qualia and consciousness have effects, and such effects can be beneficial. Thus, creating qualia and consciousness for all these important processes can yield critical advantages to the organism. It can enhance perception, cognition, emotion, memory, volitional motor functions, etc. [11,41,44,68–79]. It is probable that, because perceiving situations in the outside world correctly, analyzing them and forming responses to them effectively, and executing purposive responses appropriately, *all to the greatest possible extent*, are crucial to the being, it is *beneficial and advantageous to enhance* the mental processes that perform *these important functions* with *the combined novel functions: qualia and consciousness*. This is why qualia and consciousness evolved to occur in these mental processes. On the other hand, the lower mental processes, such as those in the basal ganglia, brain stem, and cerebellum, can perform their routine functions efficiently without qualia and consciousness. Qualia and consciousness in those mental processes are thus unnecessary and may even be disadvantageous because some resources would have to be diverted to create, operate, and maintain them. Therefore, the answer to this question is that enhancing some mental processes with qualia and consciousness is beneficial, but enhancing others is not.

9.2 Qualia and Consciousness in Animals

Do animals have qualia and consciousness?

Because similar neural processes have similar signaling patterns and signaling states, any animals that have neural processes similar to ours have similar signaling patterns and signaling states to ours. Consequently, because qualia are signaling patterns and consciousness is a signaling state, these animals should have qualia and consciousness similar to ours. Animals with brain structures, neural circuits, and neural processes fairly similar to ours, such as mammals (chimpanzees, elephants, dogs, dolphins, whales, etc.), are likely to have qualia and consciousness fairly similar to ours. Animals with brain structures, neural circuits, and neural processes less similar to ours, such as birds, reptiles, amphibians, and fish, are likely to have qualia and consciousness less similar to ours. Animals with brain structures, neural circuits, and neural processes very different from ours, such as arthropods (ants, bees, flies, etc.) or cephalopods (octopus, squid, nautilus, etc.), may have qualia and consciousness that are of different kinds from ours or may not have qualia and consciousness at all.²¹ At present, this is still under debate, but theoretically, it could be answered with more certainty if the kinds of neural circuits, neural processes, signaling patterns, and signaling states for qualia and consciousness in humans and those corresponding ones in other animals could be identified and compared.

9.3 Qualia and Consciousness in Computers and Robots

9.3.1 Do computers and robots have qualia and consciousness?

As computers and robots have parts that function similarly to parts of animal nervous systems—sensors (camera, microphone, mouse/keyboard, radiation sensor, chemical sensor, etc.), central processors and controllers (computer motherboard, robot mainboard, etc.), and effectors (monitor, speaker, printer, broadcast antenna, robotic arms/legs, etc.)—and as they use electrical signals in processing and communicating information between these parts, thus having electrical signals representing various kinds of information circulating in their circuits, it is logical to speculate that qualia-like phenomena (like an image of a red color or a sound of note C, which manifests what itself

²¹ Although many kinds of animals, especially those in these three clades—vertebrates, arthropods, and cephalopod mollusks—exhibit complex cognitive functions [11,33,36,41,44,80] and although they have neural structures and dynamics that are functionally equivalent to ours (such as the visuotopic, tonotopic, and somatotopic maps in the cerebral cortices; the thalamus; thalamo-cortical loops; cortico-cortical loops; and reentrant signaling in these loops), which are the basis of consciousness's existence and functions in humans [11,36,60,81,82], these findings are not definitive evidence that consciousness exists in them. Although many authors argue for the possible existence of consciousness in some of such animals because of these findings [11,33–35,40, 41,44,80,81,83–90], others think that this issue is still unsettled [91–94]. Thus, it is still not unanimously accepted that some animals have consciousness.

is like in our mind) may occur in their systems because some parts of their signaling might be qualia-like phenomena in the same way that some parts of human signaling, the SSPs, are qualia. At present, whether qualia-like phenomena occur in their signaling processes cannot be conclusively answered because we still do not know the specific characteristics of the signaling that can be qualia and qualia-like phenomena.

However, even if qualia-like phenomena do occur in computers and robots, they certainly do not have physical effects on any of the computers' or robots' circuits and functions because, evidently, all the circuits always function in the expected way that they are designed to do. It has never been found that circuits in computers or robots unexpectedly execute some programs because of something unidentified or that some unknown, non-preinstalled functions, such as processing information about hypothetical qualia-like phenomena being discussed, take place in them. Thus, even if qualia-like phenomena occur in computers or robots, they have no physical effects and hence are unlike qualia occurring in us, which have physical effects (see 9.1.9 above). Moreover, it is definite that present-day computers and robots, operating with present-day hardware and software, do not have consciousness—they are not aware of and do not experience any qualia-like phenomena that may occur in them. This is because awareness and experiences of anything, including qualia-like phenomena, are additional functions and have additional information. Therefore, computers and robots would need at least some specific, dedicated software and potentially some specific, dedicated circuits to perform these new functions and manage the new information, specifically the information about awareness and experiences (of the hypothetical qualia-like phenomena) that is to occur in the processes. However, there are no such software and circuits in present-day computers and robots—all the software and circuits in present-day computers and robots are created to do some predetermined, specific tasks, such as word-processing or spreadsheet operations, picture- or video-editing/displaying operations, and peripheral device (e.g., disc drive, monitor/printer, robotic arms/legs, etc.) controls. None is developed to be aware of and experience qualia-like phenomena that may occur in their circuits, and none is designed to be aware of and experience what these phenomena are like,²² because at present, we, their creators, simply do not know how to construct such software and circuits. Therefore, it is absolute that present-day computers and robots, with their current circuits and software, do not and cannot have conscious awareness and conscious experiences of anything; that is, they do not and cannot have consciousness—*awareness and experiences of what things are like*.²³ Similarly, this conclusion is true for all other present-day electronic devices and machines (mobile phones, automatic vending machines, automated industrial machines, etc.) and all current devices and machines that process information in other (non-electronic) ways (analog thermometers, analog

²² A similar concept was discussed before by De Sousa (2013) [95].

²³ Please see the meaning of this phrase at the end of Page 107.

barometers, analog odometers, etc.)—these present-day devices and machines, with their existing machinery and operating mechanisms, are not aware of and do not experience what things are like and thus do not and cannot have phenomenal consciousness. To repeat, this is simply because they do not have anything that supports occurrences and functions of conscious awareness and conscious experiences, which are consciousness.

At this point, some may argue that consciousness is a non-material phenomenon and thus may occur in a computer from something that is not the function of its electronic circuits, such as heat, moisture, chemicals, or some unknown non-material entity, or even from nothingness. However, if such is the case, then the consciousness that occurs will not have physical effects at all or will have just nonspecific instead of specific effects, which are information-based, on the computer. This is because, even though nonspecific effects on a computer's system can result from things that are not the information-processing part of its electronic circuits, such as heat, moisture, or chemicals (which can cause unplanned effects, such as glitches or more serious malfunctions in the computer's system), specific effects, which must result from registering, processing, storing, retrieving, and utilizing information, occur only from information processing by specific electronic circuits in the computer system. Moreover, in the case of consciousness that supposedly occurs from some unknown non-material entity or nothingness, this kind of consciousness will not and cannot have any physical effects on a computer because it would be a non-physical entity, which cannot have physical effects. Therefore, all these hypothetical kinds of consciousness cannot have specific effects on the computer system. Such consciousness cannot result in computers or robots having awareness and experiences of what things are like, registering its occurrence in their systems, reporting its presence to others, storing its information in memory, processing its information for other activities, and so on. Such hypothetical consciousness is thus different from our consciousness, which has specific effects and results in various physical activities, such as, in addition to the just mentioned activities, talking and writing about, having conferences on, and doing research and experiments on it.

In conclusion, although some non-material phenomenon may occur in computers or robots from something that is not part of their electronic circuits' functions and although some may call it consciousness, it cannot have specific effects on the computers or robots or cannot have physical effects at all; thus, it is not and cannot be the kind of consciousness that we mean when we think or talk about consciousness in people and that is defined in this theory.

9.3.2 How do we build computers or robots that have consciousness as we do?

To have consciousness as we do, computers and robots must be able to be aware of and experience what things are like. However, the ability to perform these two functions

needs specifically arranged circuits with specifically designed software to create electronic processes with this ability.

Theoretically, to have consciousness in an electronic system, some electronic circuits in the system must create signals that have information that means awareness and experiences of what things are like (such as what an image of red is like) to relevant circuits. In detail, this means that some circuits must create signals that have specific physical effects on signal-receiving circuits, causing them to have information that means awareness and experiences of what things are like in them. This would make the receiving circuits subsequently function with this information. For example, the reporting circuit will report that awareness and experiences of what things are like have occurred in the system, the information-storing circuit will be able to store that information in the system's memory, and the memory-recalling circuit will be able to retrieve the stored information to the central processing circuits for subsequent utilization. However, the present major obstacle is that we do not know the characteristics of *a) the electronic signals that mean awareness and experiences of what things are like to the receiving circuits* and *b) the circuits and their processes that can create such signals*.²⁴

Another possibility is that, instead of trying to create the needed circuits, processes, and signals from nothing, we could try to imitate human consciousness and qualia-producing neural circuits, their processes, and their signals (SSSs, and SSPs). Although the exact characteristics of these components remain largely unknown, theoretically, there is nothing to indicate that it is not possible for us to discover them eventually. In theory, if we have this knowledge and if the possibility of creating such circuits, processes, signaling patterns, and signaling states is not restricted to carbon-based biological systems but also applies to silicon-based electronic ones, then computers and robots with phenomenal qualia and consciousness can be built by such imitations. This concept is in accordance with Chalmers' principle of organizational invariance [3,4,96–98].

9.3.3 Can there be robots that behave identically to us but do not have qualia and consciousness?

No, there cannot. If robots do not have qualia and consciousness, they will lack information about these phenomena. Consequently, they will not be able to behave identically to us in the activities that depend on or are related to information about these phenomena. For example, they will not be able to think or talk about, have conferences on, write articles or reports about, conduct research and experiments on, and perform other activities regarding their qualia and consciousness, while we obviously can and do.

²⁴ Please see related discussions about this matter in Chapter 8, Subsection 8.1.2: "What is the mechanism for a physical signal to mean a quale?" and Extra Chapter I, Section I.7: "The Mechanism for Information to Mean a Certain Thing."

9.4 Consciousness after Conception

When does consciousness appear in a being?

Because consciousness is a composite of SSSs, it cannot appear when there are no SSSs. Accordingly, it does not appear at the moment of conception, the earliest formation of the nervous system, or the beginning of fetal brain development. Only when the consciousness neural circuit has been formed and begins producing a composite of SSSs will consciousness begin to appear. Obviously, consciousness cannot appear suddenly in the fetus but develops gradually as the consciousness neural circuit, its process, and the composite of SSSs that it produces mature little by little.

According to *Stiles and Jernigan (2010)* and *Mashour and Alkire (2013)*, the developmental anlage of the thalamus, one of the necessary structures for consciousness, is present from around day 22 or 23 post-conception, and the thalamocortical connections, another necessary structure, are thought to be formed by week 26 of gestation [45,99]. Around the same time, week 25–29, electrical activity from the cerebral hemispheres shifts from an isolated to a more continuous pattern, with sleep-wake distinctions appreciable from week 30. Thus, both the structural and functional prerequisites for consciousness are in place around week 30 [45]. According to *Zelazo (2007)*, the onset of minC (minimal consciousness) may be tied to a series of anatomical and behavioral changes that occur during the third trimester—between about week 24 and 30 of gestation [100]. Also, according to *Lagercrantz and Changeux (2009)*, after week 24, thalamocortical axons grow into the somatosensory, auditory, visual, and frontal cortices, and the pathways mediating pain perception become functional around week 29–30 [101]. In addition, from *Lagercrantz (2014)*, consciousness cannot emerge before week 24 when the thalamocortical connections from the sense organs are established; thus, the limit of legal abortion at week 22–24 in many countries makes sense [102]. Therefore, it can be concluded from these findings that consciousness, at least in some rudimentary form, plausibly begins to appear in the fetus around week 24–30 of gestation.

9.5 Remarks

Until now, numerous scientists and philosophers have proposed various theories and concepts to address the hard problem; for example, please see References 6, 13, and 103–111. However, none seems to be accepted as the conclusive answer probably because none seems to satisfactorily answer how and why phenomenal qualia and consciousness can and should arise from the physical system. This theory offers a new approach. It first identifies, based on their physical properties, what qualia and consciousness are physically. Once they have been found to be informational entities in the form of neural signals, the hard problem dissolves. Signals and their information can mean anything, including phenomenal qualia and consciousness. Therefore, when some neural processes

evolved to produce signals with these types of information, phenomenal qualia and consciousness naturally and inevitably began to appear in the nervous system, a physical system. And they should occur at some evolutionary stage because, given time and opportunities, variations resulting in new functions eventually occur. Finally, that they still exist at present likely signifies that they can help increase the survival chances of the species that possess them. Thus, the hard problem can be solved with current scientific knowledge of signals, information, and evolution.

In the past, the sun seemed like God.

*We could not answer how and why it occurred,
how and why it shone its powerful light ... and other puzzles,
until we knew what it was physically.*

Consciousness is like the sun ... and everything else.

*We cannot answer how and why it occurs,
how and why it has phenomenality ... and other puzzles,
until we know what it is physically.*

*The hard problem can be solved
by first solving the ontological problem.*

Chapter 10

Additional Theorems: Theorems VI–X

This chapter consists of two parts. Part I comprises four ancillary theorems, which are direct consequences of Theorems II and IV. Part II contains an independent theorem, which is about another important aspect of the mind.

Part I. Ancillary Theorems

The four ancillary theorems are about identities, similarities, and differences between neural processes, mental processes, and qualia.

(In this part, the symbol * stands for “in the case that the neural processes have qualia.”)

10.1 Theorem VI

Because similar neural processes have similar information-processing processes and the information-processing process of a neural process is a mental process (Theorem II), similar neural processes have similar mental processes.

Because similar neural processes have similar special signaling patterns* and the special signaling pattern of a neural process is a quale (Theorem IV), similar neural processes have similar qualia*.

Theorem VI: Similar Neural Processes have Similar Mental Processes and Qualia*.

This means that similar neural processes, such as visual perception neural processes in healthy people, have similar mental processes and qualia, such as similar visual perception mental processes and similar visual qualia.

Implications

If a person’s consciousness neural process can access and read the signaling pattern of a perception neural process (such as a visual perception neural process) of another person experiencing the same thing (e.g., looking at the same color), the first person will find that the quale that occurs in the second person’s perception neural process is similar to the one occurring in his or her perception neural process. This seems impossible to test at present, but it can be verified in craniopagus twins (conjoined twins whose craniums are fused together) who share some perception neural processes that are not significantly different.

Any animal that has a brain with similar neural circuits, connections, and physiology to those of the human brain should have neural processes similar to those of the human brain when sensing the same things that humans do. Thus, it should have similar qualia and consciousness (conscious awareness and experiences) to those occurring in human minds [1–3]. The more similar its brain is to ours, the more similar its qualia and consciousness are to ours. The more different its brain is from ours, the more different its qualia and consciousness are from ours. For example, we can infer that dogs mentally see a house in a way similar to how we do because their visual perception systems are fairly like ours (one noteworthy difference is that dogs are color-blinded by their inherent lack of some type of retinal photoreceptors and thus do not see the colors of the house as we do). Bees, on the other hand, with compound eyes, the ability to sense UV light, and other visual perception aspects that are different from ours [4], probably see the house (consciously experience a visual quale of the house) in a very different way that we cannot imagine because we cannot have neural signaling patterns similar to those in the bee brains occurring in our brains to experience.

As similar neural processes have similar qualia, variable qualia or qualia (of the same thing) that have different manifestations in the minds of similar people (such as Color C quale manifests itself as a red quale in some people, as a blue quale in some people, and as some other color qualia in some other people) are not possible. This topic will be discussed in more detail in Extra Chapter II: Variable Qualia.

Predictions

1. Craniopagus twins who can access a certain perception neural process (such as visual) of the other twin will find that the quale of something (such as the visual quale of some object) that occurs in his or her own perception neural process is similar to the quale of that thing (such as the visual quale of that object) that occurs in the other twin's perception neural process that he or she can access, provided that their neural processes for that perception are similar.
2. If, in the future, there is a way to connect neural processes of different people so that one person's consciousness neural process can access and read the signaling pattern of a perception neural process (such as a visual perception neural process) of another person who is experiencing the same thing (e.g., looking at the same color), the first person will find that the quale that occurs in the second person's perception neural process (such as the visual quale of the color) is similar to the quale that occurs in his or her perception neural process.
3. A transplanted neural tissue that results in a neural process similar to the previously functioning neural process will yield a corresponding mental process (perception, motor, cognition, etc.) and a corresponding quale (visual, motor controlling, thinking, etc.) that are similar to the previously functioning mental

process and quale. This principle is the theoretical basis for neural transplantations. According to this theorem, neural transplantations for conditions or diseases such as cortical visual impairment, Parkinson’s disease, and Alzheimer’s disease can create mental processes and qualia similar to the impaired or destroyed ones if the procedures result in correctly functioning neural processes. The success of transplantations in rebuilding neural processes can be verified by investigations such as fMRI, MEG, ECoG, and intracortical and single-unit recordings, and their success in restoring mental processes and qualia can be assessed by reports from the subjects.

4. As similar neural processes have similar mental processes and qualia, mind or thought reading and qualia identification will be possible. They can be achieved by comparing the characteristics of neural processes of mental processes or qualia in question with those of known mental processes or qualia, again by investigations such as those just mentioned above [5–9].

Remarks

The concepts behind this theorem are not novel. Similar ideas were proposed before, such as in “The principle of organizational invariance,” in which *Chalmers (1995)* said that “*any two systems with the same fine-grained functional organization will have qualitatively identical experiences*,” [10–13] and *Moutoussis (2016)* said that “... *a specific brain-activation pattern, leading to the formation of a specific percept*,” and “*specific, individual perceptual experiences are caused by specific, individual brain activation pattern*.” [14].

10.2 Theorem VII

Because different neural processes have different information-processing processes and the information-processing process of a neural process is a mental process (Theorem II), different neural processes have different mental processes.

Because different neural processes have different special signaling patterns* and the special signaling pattern of a neural process is a quale (Theorem IV), different neural processes have different qualia*.

Theorem VII: Different neural processes have different mental processes and qualia*.

This means that different neural processes in a person (such as visual-perception, emotion-generation, and thought-formation neural processes) have different mental processes (such as different visual-perception, emotion-generation, and thought-formation mental processes) and qualia (such as different visual, emotion, and thought qualia).

Predictions

1. If we examine the mental processes or qualia of different neural processes (such as neural processes in different areas in a subject), we will find that the mental processes or qualia of these different neural processes are different, which can be verified by the subject's reports of the characteristics of the occurring mental processes or qualia concurrently with monitoring the neural processes by investigations such as fMRI, MEG, ECoG, and intracortical and single-unit recordings.
2. If we cause changes to a neural process, we will also change its mental processes and qualia. This is regularly observed in clinical cases and experimental subjects. An interesting case is gene therapy for color blindness. According to this theorem, gene therapy that corrects color blindness by converting one type of existing photoreceptors to the missing type (such as converting green-sensitive cone cells to red-sensitive cone cells in people with red-color blindness) will be able to create new color perception and a novel quale in the patient. The new color perception and quale occur because they depend on the signals from photoreceptors in the retinae [15–19] and because the signals from those photoreceptors change after some of them are changed by the therapy. The changed signals from the photoreceptors will result in changed signals in subsequent visual processing centers, from retinal ganglion cells to all visual-perception processing centers in the brain, including the final color-perception neural circuit. Finally, after the consciousness neural process receives the new signal from this last circuit, it will interpret the new signal as a new color, and the patient will experience a novel color quale. This type of treatment has been performed successfully in animals such as squirrel monkeys and mice [20–23].

10.3 Theorem VIII

Because mental processes are information-processing processes (Theorem II) and similar information-processing processes require similar neural processes, similar mental processes require similar neural processes.

Because qualia are special signaling patterns (Theorem IV) and similar special signaling patterns require similar neural processes, similar qualia require similar neural processes.

Theorem VIII: Similar mental processes and qualia require similar neural processes.

This means that similar mental processes, such as visual perception mental processes in healthy people, and similar qualia, such as visual qualia in healthy people, require similar neural processes.

Predictions

1. It will be found that similar mental processes, such as visual perception mental processes in normal subjects, require similar neural processes, which can be verified by the subjects' reports of the characteristics of the occurring mental processes concurrently with monitoring the neural processes by investigations such as fMRI, MEG, ECoG, and intracortical and single-unit recordings.
2. It will be found that similar qualia, such as visual qualia of similar things in normal subjects, require similar neural processes, which can be verified by the subjects' reports of the characteristics of the occurring qualia concurrently with monitoring the neural processes by investigations such as those just mentioned above.

10.4 Theorem IX

Because mental processes are information-processing processes (Theorem II) and different information-processing processes require different neural processes, different mental processes require different neural processes.

Because qualia are special signaling patterns (Theorem IV) and different special signaling patterns require different neural processes, different qualia require different neural processes.

Theorem IX: Different mental processes and qualia require different neural processes.

This means that different mental processes (such as visual-perception, emotion-generation, and thought-formation mental processes) and qualia (such as visual qualia, emotion qualia, and thought qualia) in a person require different neural processes.

Predictions

1. It will be found that different mental processes, such as visual-perception, emotion-generation, and thought-formation mental processes in a subject, require different neural processes, which can be verified by the subjects' reports of the characteristics of the occurring mental processes concurrently with monitoring of the neural processes by investigations such as fMRI, MEG, ECoG, and intracortical and single-unit recordings.
2. It will be found that different qualia, such as visual qualia, emotion qualia, and thought qualia in a subject, require different neural processes, which can be verified by the subject's reports of the characteristics of the occurring qualia concurrently with monitoring the neural processes by investigations such as those just mentioned above.

Obviously, the two predictions are regularly found to hold in clinical and experimental cases, such as visual and auditory qualia require different neural processes. More difficult but more critical theoretically is to prove that the perception of a certain object without qualia occurring and the perception of that object with qualia occurring requires different neural processes. Indeed, Theorem IX and the closely related theorems, Theorems IV and V, will be invalidated if it is shown that the perception of a certain object A without qualia occurring and the perception of that object A with qualia occurring do not require different neural processes—the concepts of neural processes with special kinds of signaling patterns and signaling states (the SSP and SSS), which function for qualia and consciousness, will be unnecessary and false.

Part II. Mental Interactions are Physical Interactions

10.5 Theorem X

Let us consider the following illustrative example of mental interactions: A mother, seeing her beloved child wandering into the street and about to be hit by a speeding car, decides without hesitation to save her child by jumping into the street, even though this decision means risking her own life. Obviously, her love for the child must be able to affect her thinking, planning, and decision making and cause her to carry out such a life-risking act. However, how can feelings of love affect other mental processes, such as thinking, planning, and decision making? The obvious mechanism is that, as mental processes are information-processing processes of neural processes (Theorem II), interactions between them occur through information transmission between the involved neural processes via their synapses. Thus, mental process interactions are physical interactions between neural processes. This conclusion is also supported by the fact that, at present, exceptions to the principle that the world is physically causally closed have not been found. Hence, all observable events, including interactions between things, must be physical.

10.5.1 Mental force

Nevertheless, no physical laws or principles are truths; they are subject to change with new evidence. Thus, the possibility exists that mental process interactions are not physical. Accordingly, let us examine the possibility that mental processes interact directly between themselves, without utilizing neural synaptic transmissions and any of the four fundamental forces, to learn more comprehensively about this matter as follows:

As just mentioned, this kind of mental process interaction, which has long been suspected to exist and some people still believe in, is supposed to utilize a force that is none of the four fundamental physical forces. This force is called a mind force, mental force, or mental force field [24–29]. To qualify as a mental force, the force must be directly executable by mental processes and must directly affect other mental processes

on its own. As a mental process exists and functions with a certain neural process (Theorem I), when the mental process is affected by a mental force, this neural process must also be affected similarly so that, functionally, they remain in accordance with each other. This implies that the mental force must affect the neural process in the same manner as it does the mental process. This, in turn, means that the mental force must correctly affect all membrane and synaptic channels of millions of neurons in the involved neural circuit. Furthermore, it must accurately move an uncountable number of sodium, potassium, calcium, and chloride ions at the correct channels in the correct manner (e.g., correct amounts of sodium, potassium, and calcium ions are moved at the correct rate, in the correct direction, and at the correct time in each channel in a concerted pattern). These ion movements must bring about appropriate polarizations or depolarizations at the right places and time, resulting in appropriate action potentials or no action potentials in millions of neurons in the neural circuit [30–36]. This entire process must cause the neural process to change identically to and in perfect unison with the mental process that has changed because of the mental force.

The main questions about this mental force are as follows:

1. What is the nature of this mental force?
2. How can this force know which neural circuit among innumerable circuits in the brain is the one to affect—the one that has to be changed in accordance with the mental process that this mental force affects?
3. How can this force determine the exact spatial positions of all neurons in the targeted circuit so that it can affect all of them precisely?
4. How can this force correctly affect millions or billions of neuronal membrane and synaptic channels, both spatially and temporally, and correctly move countless different ions so that the targeted neural circuit's process changes in accordance with the mental process?
5. Energy must be expended or gained in affecting the membrane and synaptic channels and moving ions across channels. Where does this force draw energy from or channel the gained energy to, and how does it execute such actions?

Evidently, affecting a neural process correctly so that it changes in harmony with the associated mental process that has been changed is not a simple physical process. Nevertheless, if a mental force exists, it must be able to do so. However, to date, there are no answers to how such a complex execution can be achieved by an unconventional physical force.

10.5.2 Mental process interactions

In contrast, abundant evidence indicates that mental process interactions occur via signal transmission through synaptic connections between the involved neural processes.

Let us examine how mental process interactions occur through this means. Because the example at the beginning of the chapter is a typical case, we will use it as a case study. When one mental process, such as that for the visual perception of seeing a child in danger, functions, its associated neural process will send the information about this perception, in the form of signaling patterns, through synaptic connections to other neural processes of other mental processes. These information-receiving neural processes will process this information and generate signaling patterns that are their new, specific information (i.e., a decision to save the child, emotion of fright, retrieval of relevant past knowledge and experience of how to save the child, etc.). This newly generated information will likewise be sent to related neural processes via synaptic transmissions. This process will continue successively, creating successive signaling patterns, which are successively processed information related to the incident. Finally, the decision-making neural process will create signals representing the decision to jump into the street to save the child and send the signals to related neural processes to perform the action. Mentally, this moment is when the woman's mind makes the decision. Overall, because synaptic transmissions can integrate transmitted signals [32,36–49], synaptic transmissions can both transmit and process information. Thus, coherent and appropriate mental process functions for problem solving and other activities can occur via synaptic transmissions.

Evidence indicates that mental process interactions indeed occur through neural processes and synaptic transmissions. Anything affecting neural transmission at synapses or neural tracts that connect the involved synapses can affect mental process interactions. Pharmacologically, central nervous system (CNS) active substances that interfere with synaptic transmissions, such as psychedelic drugs, CNS stimulants, and tranquilizers, alter mental process interactions according to which synaptic transmissions they affect and how they affect them, such as causing hallucination, excitement, or tranquility [50–53]. In patients with CNS diseases that have synaptic transmission dysfunctions, such as bipolar disorder, major depression, anxiety disorders, Alzheimer's disease, and Parkinson's disease, drugs that can help correct or improve abnormal synaptic transmission can correct or improve the functions of the corresponding neural processes, mental processes, and their interactions, such as improve mood, cognition, and motor control [54–60]. A transection of a CNS nerve tract can affect mental processes' interactions and their functions; it can be used to treat mental disorders (such as depression), pain, and epilepsy [61–64]. A corpus callosum transection, which is done in some cases of intractable epilepsy, has observable mental effects called “split-brain syndrome,” in which some mental processes on one side of the brain cannot communicate with others on the other side of the brain and in which there is impaired functional connectivity between some modules between the two hemispheres [65–70]. Diseases that damage the neural tracts disrupt signal communication between the connected neural processes and the corresponding mental processes, resulting in various syndromes depending on which connection is damaged. For example, conduction aphasia occurs

when the left hemisphere arcuate fasciculus (which connects the sensory and motor language areas) is destroyed [71,72] (such as in the case of cerebral infarction), and pseudobulbar affect (uncontrollable crying or laughter) occurs when the corticopontine-cerebellar circuits (which are part of emotion control) are disrupted (such as in the case of stroke or motor neuron disease) [73]. Additionally, because mental process interactions occur not only through synaptic transmissions but also through the involved neural processes, anything that affects neural processes affects mental process interactions and their functions. This has been demonstrated and discussed in detail in the discussions of physical properties of the mind and mental process in Chapter 1.

10.5.3 Theorem X

Therefore, based on existing evidence, it is not logical to conclude that mental process interactions or, to be concise, mental interactions occur through some unknown, non-fundamental force. Instead, it is rational to conclude that they are neural process interactions mediated by conventional physical forces through neural synaptic transmissions. This theory asserts this conclusion as a specific form of Theorem X:

Theorem X: Mental interactions are neural process interactions.

As neural process interactions involve the generation and propagation of action potentials along axons, dendrites, and somas and through neural synapses, and as these activities are physical activities, neural process interactions are physical interactions. Consequently, mental interactions are physical interactions. This is the basic form of theorem X:

Theorem X: Mental interactions are physical interactions.

This means that physical laws can describe and predict mental interactions. For example, the effects of love, hate, or aspiration on other mental processes, such as thinking, planning, and decision-making, are physical effects and can ultimately be described and predicted by physical laws. The predictions can be definite or probabilistic, depending on the physical laws involved.

10.5.4 Predictions

1. A mental interaction can be created, identified, measured, monitored, changed, or destroyed by performing the respective actions on its neural process interaction. These actions on the neural process interaction are both necessary and sufficient for the corresponding actions on the mental interaction to occur, and these actions on anything else without involving the neural process interaction will not result in the corresponding actions on the mental interaction.

Note. A neural process interaction can be identified as the neural process interaction of a mental interaction through investigations that observe and may also manipulate various neural process interactions concomitantly with observing the mental interaction. In various investigations, the neural process interaction that consistently changes correspondingly with the mental interaction will be the neural process interaction of that mental interaction.

2. It will be found that, in an event or experiment, all predictions valid for a certain neural process interaction, such as whether the interaction will begin, change, or cease, will be identically valid for the mental interaction associated with that neural process interaction.
3. If all the physical factors involved in a mental interaction (such as the characteristics of the associated neural process interaction) are known, the result of the mental interaction will be predictable. For example, when a person is given a choice between two things, such as a house or a car, if all the physical factors involved are known, it will be predicted definitively or probabilistically (depending on the involved physical laws to be discovered) what he or she will choose.

Extra Chapter I

Information

I.1 Information: Definition

Information is a term that has various meanings depending on several factors, such as who is using the term (layman, engineer, philosopher, etc.) and the context in which the term is being used (non-academic, engineering, philosophical, etc.) [1–9]. Some uses of this term, although frequently referred to in the literature, are technical and not in the ordinary, daily life sense. For example, “information” in “A Mathematical Theory of Communication” [7], despite not being definitively defined in the theory, is widely cited and used to denote something that, when present as an element in a set, carries more weight or possesses more amount if it is unlikely to occur in that set than if it is otherwise [7,10]; information is what is produced by its source that is required to be reproducible at the destination if the transmission is to be counted as a success [9]; and information is a difference that makes a difference [11]. For general people, these descriptions can be confusing and lead to misinterpretation. Unfortunately, there is no consensus on its definition, even within a single discipline. Nevertheless, a definite definition of information is essential in a scientific work to avoid inconsistency in the work and confusion and misunderstanding among those who study the work. Therefore, a working definition will be established for this study. This theory aims to use “information” that has meaning in an ordinary, daily-life sense. To seek an appropriate definition for such a term, let us spend some time examining the uses of “information” in some ordinary, daily-life usages as follows:

- 1. The couple gets information from the salesperson that the house was built with high-grade materials and by a reputable construction company, so they decide to buy it.*
- 2. Both factual and false information from various sources circulate in social media and can affect the opinions and behaviors of those who believe them.*
- 3. This science textbook, written by a renowned author, contains important scientific information, which can greatly enhance readers’ knowledge.*
- 4. The electromagnetic (EM) waves broadcasted from a TV station comprise visual and audio information, which will be converted to images and sounds on TVs.*
- 5. The animal gathers information from the surroundings to determine how to move safely along the terrain and find food.*

From these common usages, we can see that the shared essential characteristics of the terms “information” are that each term refers to ***a non-material thing that is transferable from one physical entity to another, consists of content, and can have physical effects on the receivers***. The examples can be rewritten to explicitly demonstrate these essential characteristics as follows:

1. Information from the salesperson is non-material. It is transferable from the salesperson to the couple, consists of content—an account of what the house was built with and by whom it was built—and can have physical effects on the couple’s decision.

2. Information in social media is non-material. It is transferable from the publishers to the social media to the social media consumers, consists of content—news, stories, comments, predictions, lessons, etc.—and can have physical effects on the consumers’ opinions and behaviors.

3. Information in the textbook is non-material. It is transferable from the author to the textbook to the readers, consists of content—descriptions and discussions of scientific discoveries, experiments, research, theories, formulas, and other scientific matters—and can have physical effects on the readers’ knowledge.

4. Information in the EM waves is non-material. It is transferable from the TV station to the EM waves to the TVs, consists of content—virtual images and sounds—and can have physical effects on the TVs’ video and audio systems.

5. Information about the surroundings is non-material. It is transferable from the surroundings to the intervening media (e.g., air, water, and soil) to the animal, consists of content—the surroundings’ characteristics (visual, audio, smell, taste, tactile, etc.)—and can have physical effects on the animal’s behavior.

Before we set up the definition, let us examine three more examples to see whether this plausible definition is also valid at the nervous system, neuronal, and intracellular levels, the first two of which are the principal realms that this theory involves.

6. The information in the optic nerve when one looks at the outside world tells the brain what the outside world looks like.

Information in the optic nerve is non-material. It is transferable from the outside world’s objects to the object’s reflected lights, to the retina, to the optic nerve, and finally to other parts of the brain; it consists of content—visual characteristics of the outside world; lastly, it can have physical effects on the brain (by enabling the brain to know what the outside world looks like).

7. Information about past events is embedded in the neural synaptic structures and can be retrieved to be used at present by the neural processing system to make appropriate decisions and responses.

Information about past events is non-material. It is transferable from the past events to the neural synaptic structures to the current neural processing system; it consists of content—an account of past events; lastly, it can have physical effects on the processing system (in making decisions and responses).

8. The biological information that determines the anatomical, physiological, biochemical, and other biological characteristics of an organism is stored in the genes and exerts its effects via the mRNAs and the protein synthesis system.

The biological information in the genes is non-material. It is transferable from the genes to the mRNAs to the protein synthesis system; it consists of content—anatomical, physiological, biochemical, and other biological characteristics of the organism; lastly, it can have physical effects on the organism (by determining all the biological characteristics of that organism).

Clearly, that information is ***a non-material thing that is transferable from one physical entity to another, consists of content, and can have physical effects on the receiver*** is also true in these realms. Therefore, as this essence seems to be generally applicable, it is reasonable to use it as the basis for our working definition.

However, several issues must be considered prior to establishing a proper definition. **First**, the “non-material thing” in this usage means something that is not composed of the elementary particles of the Standard Model. Therefore, light and other forms of EM waves, although “non-material” in general usage because they are composed of massless photons, are not “non-material things” in this definition because they are composed of photons, which are elementary particles. They thus cannot be this theory’s “information.” At this point, it should be noted that, although information can exist in light and other EM waves, such as in Example 4 above, the light and EM waves themselves are not information, but some non-material thing in them is. What this non-material thing is will be identified later. **Second**, because the word “transferable” in this context already means “able to be moved from one entity to another,” the phrase “from one physical entity to another” is unnecessary. **Third**, because information is a thing (a non-material thing) and a thing always consists of something (otherwise, it would be nothing), information always consists of something, which this theory calls content. Therefore, stating that information is a non-material thing already means that it consists of something; thus, the phrase “consists of content” is not necessary either. **Fourth**, when information is transferred to or read by a receiver, the receiver will always have to process the information. Thus, the receiver will always be changed physically, at least temporarily, because of the entailed processing of the transferred information. The final change can range from trivial to significant, but the extent to which the receiver will finally change is another matter. The matter right now is that, if information is transferred to or read by a receiver, the information will always have some physical effects on the receiver. Hence, the phrase “can have physical effects on the receiver” is not necessary in the definition either.

Based on the above considerations, the working definition of information in this theory is as follows:

Definition: Information is a non-material thing that is transferable.

Please be reminded that this working definition is a concise version of the longer, detailed definition: *Information is a non-material thing that is transferable from one physical entity to another, consists of content, and can have physical effects on the receiver.* We will see that this kind of information is a basic component of this universe and that various important entities, such as the mind, qualia, and consciousness, will be found to be composed of it in various forms. For now, let us examine this “information” in more detail first.

I.2 Information Carrier

Because information is transferable between physical entities, it must exist in one physical entity before and in another after the transfer. Therefore, information must always exist or be embodied in some physical entity [12,13], which will be called *an information carrier* or, in short, *a carrier*.²⁵ For example, in the first five examples in Section I.1, the information carriers are 1. speech sound, 2. electronic media, 3. printed texts, 4. EM waves, and 5. physical components of the surroundings.

It can be noted that information carriers can be either static or dynamic. Static carriers do not change their structures during information transfer, whereas dynamic carriers do. Examples of static carriers include paper and other stable materials that can bear visible or tactile signs (plastic, wood, metal, etc.), magnetic tape, hard disks, optical discs, solid-state drives, and various biological molecules/structures (e.g., blood group antigens, human leukocyte antigens, DNA, etc.). Examples of dynamic carriers include sound, electrical, and EM waves. In fact, all physical objects, including elementary and quantum particles, carry information [13,14]. The reason for this will be clear after we understand the nature of information in Section I.4.

Regarding the nervous system, which is the principal system that this theory studies, the major carriers of information sent between its basic components, neurons, are a) electrical signals in the form of propagating action potentials at the membranes of axons, dendrites, and somas; synaptic potentials at the synapses; and end-plate potentials at the neuromuscular junctions, and b) chemical signals at synapses and neuromuscular junctions using various neurotransmitters. The major carriers of information stored in this system are the structures of synapses and neural circuits [15–23].

²⁵ Although some authors believe that information could exist alone by itself (without a physical object), this issue is still controversial [2]. Such information, if existing, is not information that is discussed in this theory because it is not transferable from one physical entity to another, as required by the definition. Thus, it will not be discussed further.

I.3 Information Content and Its Meaning

As discussed in Section I.1, information consists of content. Because information is non-material, its content must also be non-material. For example, in the first five examples in Section I.1, the information content is 1. an account of what the house was built with and so forth, 2. news, stories, comments, and so on, 3. descriptions and discussions of various scientific matters, 4. virtual images and sounds, and 5. characteristics of the surroundings; clearly, all these kinds of content are non-material.

Regarding its function, the information content is a representation of something or means something to a receiver. That something can be anything—it can be material or non-material and range from very simple to very complex and from virtually meaningless to extremely meaningful. For instance, in Examples 1, 2, and 3 in Section I.1, the information content represents something non-material (1. an account of ..., 2. news, stories, comments, ... 3. descriptions and discussions of ...), while in Example 5, it represents material things (the surroundings), and in Example 4, it represents both non-material and material things (e.g., non-material stories and material objects in the broadcasted movie). Some examples concerning information complexity are as follows: The information content of a head signaling by nodding or shaking means, to ordinary people, yes or no, which is very simple and requires just 1 bit to represent in the electronic binary system, whereas the information content of a radio wave streaming from a digital TV station that broadcasts a movie means, to digital TV processing systems, the movie, which is very complex and requires gigabytes or more to be represented in the electronic binary system.

The meaning of information content depends not only on the content itself but also on the receivers and the context of the information transfer. For example, the information content in the last two examples above is meaningful to its receivers. However, if the receivers in the former case were animals and those in the latter case were analog TV processing systems, the content of the same information would be practically meaningless to the receivers in both cases. Some examples regarding the context are: If the head nodding or shaking is done in some countries, such as Bulgaria, it will represent no or yes, respectively, instead of yes or no, as in most countries; or if it is done while a person is testing something, such as tasting a food or drink, it will represent approval or disapproval, respectively, instead of yes or no. This matter will be analyzed in more detail in Section I.5. However, the important point at this juncture is that the content of information represents something or means something, which can be anything, to the receivers.

Theoretically, because information content can mean anything, some information content can mean qualia (phenomena that manifest what they are like in the mind) and consciousness (awareness and experiences of such phenomena) to some receivers.

Therefore, if the nervous system can somehow create information content that means qualia or consciousness and send it to some neural process that can interpret this information, then qualia or consciousness will appear in that neural process, and thus in the brain. This is the principle underlying how phenomenal qualia and consciousness can occur in the physical brain. It is discussed in detail in Chapters 3 to 7.

I.4 The Nature of Information

Now, let us find the solution to a fundamental question about information: What is information's physical and ontological nature?

Similar to the mind, qualia, and consciousness, the answer can be found by considering its physical properties as follows:

As discussed in the previous sections, information a) is a non-material thing that is not composed of elementary particles, b) is transferable between entities, c) always exists in a carrier, d) consists of content that can mean anything (from very simple to very complex), and e) can have physical effects on the receiver. The entity that is information must also have these properties. Now, if we examine the information and its carriers in all the examples discussed, we will find that the only entity with all these properties is *the pattern of each carrier*. This is because a) the pattern of any carrier is a non-material thing that is not composed of elementary particles (although its carrier is), b) the pattern is transferable between entities because a receiver can read, that is, receive, it into its system for subsequent processing, c) the pattern of a carrier always exists in the carrier (a simple fact), d) the pattern of a carrier can consist of content that can mean anything because patterns, in general, can vary infinitely (from arbitrarily simple to arbitrarily complex), and the pattern of a carrier can be any of these infinite patterns, and e) the pattern can have physical effects on the receiver because of the entailed pattern processing in the receiver. Therefore, it can be concluded that ***information is the pattern of its carrier***.

It is important to note that the pattern of a carrier refers to ***the arrangement of the carrier's components in space and/or time***, so a pattern can be spatial, temporal, or spatiotemporal. An obvious example is the pattern of dots or pixels appearing as the text the reader is reading. The pattern is a non-material thing; it is transferable from the paper or electronic screen to the reader (i.e., the reader can read the pattern and take it into the reader's processing processes); it always exists in the ink dots on the paper or electronic pixels on the computer screen (without the dots or pixels, the pattern cannot exist); it consists of content, which, in this case, is a discussion about the nature of information, but can vary because the dot or pixel pattern can change to any pattern to represent anything; lastly, it can have effects on the reader (e.g., alter the reader's knowledge, concept, and activities). An example of a temporal pattern that is information is the Morse code, which utilizes patterns of signals with different time durations. The

temporal pattern of Morse code is a non-material thing; it is transferable from the sender to the receiver; it always exists in the time durations of the signals (sounds, flashes of light, pulsations of something, etc.); it consists of content, which in this case is a letter to be sent, but which can vary because the patterns of signals with different time durations can change to represent or mean anything; lastly, it can have effects on the receiver (such as changing the receiver's knowledge).

That information is the pattern of its carrier is also true in the examples in Section I.1. For example,

- *The information that the salesperson tells the couple is his sound pattern. If his sound pattern changes, the information will change; that is, he tells the couple something else.*
- *The visual and audio information broadcasted from the TV station is the patterns of EM wave frequency and amplitude. If these patterns change, the visual and audio information will change, and the resulting images and sounds on the TV will change.*
- *The information of an image in the optic nerve is the pattern of electrical signaling in the nerve. If this signaling pattern changes, the information will change, and the brain will receive a different image.*

Information can be either static or dynamic [6]. During information transfer, static information does not change its content (such as information on paper, on a solid-state drive, and in a DNA base sequence), whereas dynamic information does (such as information in live reports, movies, and analyzing electronic circuits). Both types of information are embodied in carriers by being the spatiotemporal patterns of the carriers (such as the patterns of dots on a paper, bits 0 and 1 in a solid-state drive, base sequences in a DNA strand, frequency and amplitude of sound waves, and duration of sounds).²⁶ In the nervous system, both static and dynamic information are carried principally by electrical or electrochemical signals in neural circuits in the form of signaling patterns (information sent to other neural circuits) and signaling states (information circulating in the entire neural circuits). For later use, both kinds of information are stored in the patterns of synaptic or circuit structures [6,15–26]. For example, when the visual perception neural circuit has finished the process of perceiving the vision of a house, it will have signals circulating in its circuit in a particular pattern—it will be in a certain signaling state—that is the information about the visual perception of the house. When it communicates this information with other neural circuits, it will send signaling patterns that are this information via its axons to the other neural circuits. When the information

²⁶ *It should be noted that static information (such as a still image) can be carried by both static carriers (such as a paper or a solid-state drive) and dynamic carriers (such as an EM wave) and that, similarly, dynamic information (such as a movie) can be carried by both static carriers (such as a solid-state drive) and dynamic carriers (such as an EM wave).*

about this visual perception is stored for later usage, it will be embodied in certain synaptic or circuit structures in the brain.

Thus, **information is the spatiotemporal pattern of something—specifically, of its carrier**. This agrees with other authors who have realized this fact before. For example, **Roederer (2016)** said that “*Pragmatic information is encoded in the brain dynamically in short-term patterns of neural impulses and statically in the long-term patterns of synaptic architecture.*” [6]; **Timpson (2013)** said that “*The basic idea is of a pattern or structure: something which can be repeatedly realized in different instances; and perhaps realized in different media.*” [9]; **Imari et al. (2016)** said that “*The signature of biological structure uncovered by our analysis therefore lies not with the underlying causal structure (the network topology) but with the informational architecture via specific patterns in the distribution of correlations unique to the biological network.*” [27]; **Földiák (2013)** said that “*Such symbols are not limited to words in a human language; they can be arbitrary patterns on a wide variety of possible physical carriers. They can be sent in a letter, or over a fiber optic cable with minimal cost in energy and time. For example, information can be encoded by ink marks on paper, a lit candle in a window, flags on a ship,*” [28]; and an entry in **The Oxford Pocket Dictionary of Current English** states that “*(Information is) what is conveyed or represented by a particular arrangement or sequence of things*” [29].

In the most basic concept, because every physical object has components and each component can exist in various states, **every physical object always has a pattern—a pattern composed of its components in particular states**. For example, object O (Figure I.1) comprises two lines, thus having the two lines as its components, and its components (lines) can exist in various states (such as in various directions, as shown in the figure); hence, object O always has a pattern composed of these two lines, each in a particular state (a particular direction, as illustrated in the figure). Some patterns, among infinite patterns that object O can have, are as shown below:

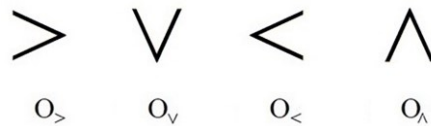


Figure I.1 Patterns of an object O comprising two lines

To repeat this important point, because object O consists of two lines and the two lines always exist in some states, composing some patterns, it is inevitable that object O always has a pattern in some form—it cannot exist without a pattern.

The last statement above applies to all objects, including a single elementary particle. Every elementary particle has several characteristics, such as spatial position, velocity, mass/energy, electrical charge, and spin [30–33], all of which can be considered

components of the particle. Accordingly, we can think of these characteristics as the above lines, which are components of object O. Because each of these characteristics can exist in various states (in the same way that each of the two lines above can exist in various directions), every elementary particle always has a pattern composed of its component characteristics in particular states (in the same way that object O always has a pattern composed of its component lines in particular directions).

Because every physical object always has a pattern and information is the pattern of a physical object, ***every physical object always has information***. This fact includes every single elementary particle because every single elementary particle always has a pattern, as just discussed.

Finally, it should be noted that, although an information carrier is a physical object, composed of elementary particles, the information or pattern of its carrier is not composed of them. Hence, information basically differs from its carrier and all other entities that are composed of elementary particles, which are called conventional physical or mechanical entities (see Physicalism and dualism, Section 2.4), such as all material things around us, lights, and other EM waves. This is why information appears very different from these conventional physical entities.

I.5 Information's Effects and Semantic Information

As discussed in the previous section, the pattern of a carrier is the information that is embodied in that carrier. However, it is essential to note that, although the pattern of a particular carrier or the information embodied in that carrier is fixed, the interpretations of the pattern or information by different receivers vary. As a result, the meaning to and the effects on the receivers vary. Theoretically, for a certain pattern read by different receivers, an infinite number of interpretations with different meanings and effects exist. This is because, for a certain pattern and information, the interpretations, meanings, and effects depend not only on the pattern or information itself but also on the receivers and contexts of information transfer, the latter two of which can vary without limits.

For example, for a hand raising two fingers, as shown in Figure I.2, the pattern of the fingers or the information embodied in them can mean two, victory, or the letter "V" to general people, but it means nothing specific to animals, babies, and people who do not use these conventions. Also, whether it means two, victory, or the letter "V," what its effects on the receivers, and what the receivers' final states are depend on, for instance, whether the receiving person is waiting to know how many concert seats are available, whether his or her soccer team has won or lost, or what the letter that is missing in the word "li_e" is. Because the variability of the receivers and contexts is limitless, there can be infinitely different meanings and effects for this two-finger pattern.



Figure I.2 Two-finger Pattern

Regarding the final effects of information, we can conclude from the previous discussions that *a) if information is meaningful to the receiver*, that is, if it means something specific to the receiver (such as those meanings in Examples 1 to 8 in Section I.1; or two, victory, or the letter “V” in the above example; or in general, an answer to a question of whether, what, who, whom, which, when, where, why, or how [34]), *it will have specific effects* that finally change the receiver into a significantly different physical state (such as those in eight examples in Section I.1) and *b) those final effects and the resulting states are different for different meanings* (such as different resulting states of peoples interpreting different meanings of the two-finger pattern in the example above). On the other hand, if information is meaningless (that is, if it does not mean something specific but is just a nonspecific input to a receiver), it will have only nonspecific effects that will not change the receiver into a significantly different physical state. These nonspecific effects result from the receiver’s regular physical processing of any received information. They finally dissipate and, ultimately, do not change the receiver into a new physical state (such as in the case of animals or babies seeing the two fingers in the example above). Hence, it can be concluded that *the meaning of information to a certain receiver is the effect of the information on that receiver*.

As already discussed, the meaning and effect of information depend not only on the pattern of the carrier but also on the receiver and context. Interestingly, in some cases, different patterns (different information) can yield the same effects on the same receiver in the same context. For example, after Alice asks Bob what number she has to jot down on the paper, Bob can say three, raise three fingers, or show a card with “3” on it, and normally, Alice would write three on the paper for each signal. This means that the different patterns of Bob’s signaling, which are different information, have the same effects on and meanings to Alice. Such different information with the same effects is said to be semantically the same. That is, *when different patterns (different information) have the same effects on the receiver, they have the same meaning to the receiver and are thus semantically the same*. Vice versa, *different patterns (different information) have*

the same meanings, are semantically the same, and are the same semantic information to the receiver if they have the same effects on the receiver.

This concept has been expressed before: **Casagrande (1999)** said that “*Marking [of information] can occur by one person rearranging patterns of meaning (e.g., color and form in the case of modern art) so that they are only recognizable at a specific epistemological level. Marking also relies on the ability of the receiver to recognize meaning in patterns.*” [35], and **Dubrovsky (2019)** said that “*When I say to a student: ‘Come up to me!’ and he performs this action, it is caused and determined not by the physical properties of the words I uttered but namely by the information expressed with their help, its semantic and pragmatic features. ... I can cause exactly the same effect to be brought about by other words and, in general, by signals very different in their physical properties (by virtue of the principle of invariance of information with respect to the physical properties of its carrier...)*” [36].

The last interesting question in this section is: What is the amount of information (AOI) of a piece of information? The answer depends on what we mean by AOI. If we define it as something that quantitatively correlates with the information’s effects, then the AOI of a piece of information depends on *what the receiver and the context of the information transfer are* (because information’s effects vary with these two factors, as discussed above). Therefore, because its effects are variable, a piece of information does not have a fixed AOI associated with it. However, AOI can be defined in other ways. If we define the AOI of a piece of information as something quantitatively correlates with the number of characters, electronic bits, or other physical items employed to represent that piece of information in communication, then the AOI of that information piece will be fixed (not dependent on the receiver and the context of the information transfer) but depend on how we represent it. For example, the AOI of **consciousness** and 意识 (the Chinese word for consciousness) are fixed at 13 and 2 characters, respectively, regardless of the receiver and the context of information transfer. Notably, the AOI of these two pieces of information is different even though they represent the same thing. The AOI of a piece of information may also be defined in yet other ways. One definition that is important in communication engineering can be inferred from **Shannon’s theory (1948)** [7]. In this case, the AOI of a piece of information is something that quantitatively correlates with the improbability of the occurrence of that information piece in a set of pieces of information—the greater the improbability (or the more uncertainty or surprise), the more AOI. It should be noted that, similar to the second definition above, this kind of AOI is fixed for a piece of information (not dependent on the receiver and the context of the information transfer). Hence, for any piece of information, the AOI by these last two definitions is always the same for all receivers regardless of its meanings and effects, which may differ among those receivers.

Summarily, the amount of information (AOI) of a piece of information depends on its definition. In some definitions (such as the first definition above), it is variable and depends on what the information receiver and the context of the information transfer are. In others (such as the last two definitions above), it is fixed for a certain representation of that information piece but still varies and depends on what the representation is.

I.6 How Information Can Exert Effects

The next crucial question is how information, which is a non-material, non-conventional physical entity, can affect a conventional physical system.

This answer can be found by examining what happens in information transfer. First, consider a case of a woman waiting for information from a man regarding the number she must say. When the information is given by the man by raising two fingers and the woman sees them, she receives the required information and speaks out the correct number. Superficially, it seems that the information leaped from the signaling man to the woman and somehow made the woman say the number correctly (as illustrated in Figure I.3).

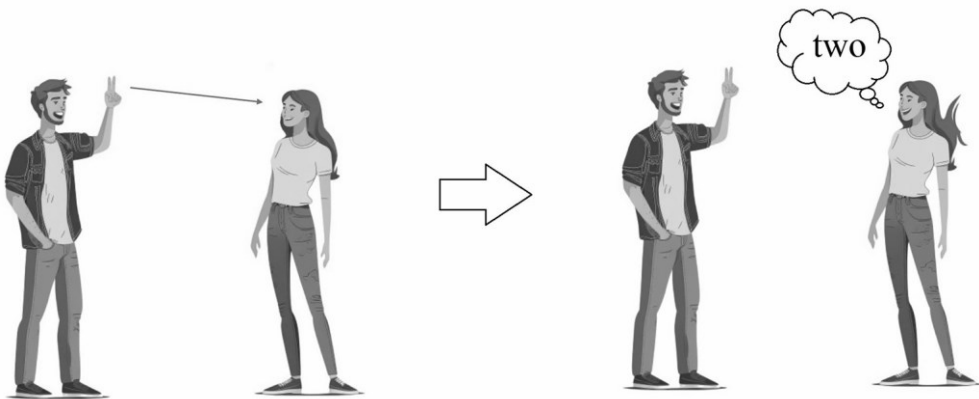


Figure I.3 Information leaping from the man?

However, what actually happens is that a) streams of photons reflected from the information source (the fingers) hit the woman's retinae, creating electrical signals there, b) the created signals thereafter run along the optic nerves and then the optic tracts to the primary visual processing circuits and then to many subsequent visual processing and other related circuits in the woman's brain, including those for language, cognition, and motor command, and c) after the signals are processed by those complex processing circuits, the final signals are created that make the woman's vocalizing organs produce the sound "two" correctly. All these events are predictable physical cascades of electromagnetic, electrochemical, biochemical, and, finally, mechanical interactions

involving only conventional physical components of the information source, intermediate information carrier (the light waves), and woman's processing systems. Nowhere in the chain of these cascades does anything other than two fundamental physical forces (mainly the electromagnetic force with some gravitational force later) exert effects on these conventional physical components. Thus, this event is just an ordinary physical phenomenon in a very complex way, with only conventional physical entities and laws involved—neither any new physical entity nor any new physical law is involved in these physical interaction cascades. Hence, it may seem that the entire process occurs without any effects from information, and information is merely an invented, redundant concept.

Nevertheless, despite the seeming redundancy, information is not a dispensable or imaginary entity—information does exist as an entity in the universe, has physical effects, and cannot be rid of. This matter can be demonstrated as follows:

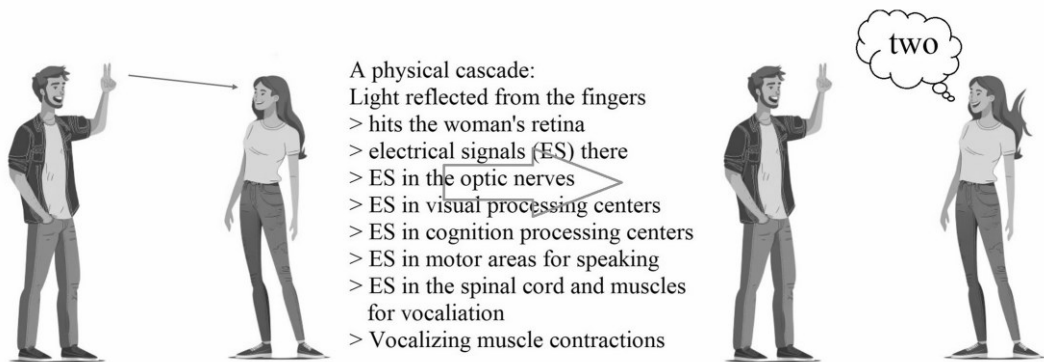


Figure I.4 How information exerts its effects

Let us reconsider what happens in the information transfer in the previous example. We will see that the entire process and final result of the information transfer, in fact, depend on the initial characteristics of the interacting systems, which include the information source, receiver, and surrounding systems. In each system, the initial characteristic is the initial pattern of all the physical characteristics (the spatial position, velocity, mass/energy, etc.) of the constituent particles. These initial patterns of the three systems are the determinants of their initial interactions, which determine subsequent interactions and, ultimately, the final result. Therefore, because the source's information is the initial pattern of the source system, it is one of the three factors that determine how the entire process initiates and proceeds and what the final result is. If the initial patterns of the other two systems remain the same, the whole process's development and final result will vary with the initial pattern or information of the source system only. In the above example, the pattern of the man's gesture (the two fingers) is the initial pattern of the source system. This initial pattern determines what will happen and what the final

result will be for the woman. If this pattern changes, such as if the man shows three fingers, even though the woman and the surroundings do not change, the initial characteristics of the three systems will change, and the entire process and final result in the woman will change. On the contrary, if the pattern (the two-finger pattern) does not change, even if the man is replaced by another man, a woman, a child, a robot, etc., the overall initial characteristics of the three systems will essentially not change, and the entire process will practically be the same, with the same final result in the woman: She will say “two.”

Hence, although the source’s information does not affect each of the innumerable physical interactions in these complex interaction cascades directly by being the forces or physical components involved, it affects the entire interactions and final result from the very beginning by being the initial pattern of the physical components of the information source. Because such effects from information cannot be removed, information does have physical effects, exists as an entity in the universe, and cannot be eliminated.

It should be noted that this concept is similar to previous notions by other authors. For example, **Madden (2000)** said that “*information should be defined as: a stimulus originating in one system that affects the interpretation by another system of either the second system’s relationship to the first or of the relationship the two systems share with a given environment...*” [5]; **Lombardi et al. (2015)** said that “*Peter Kosso states that ‘information is transferred between states through interaction.’ (1989, p. 37). The need of a carrier signal sounds natural in the light of the generic idea that physical influences can only be transferred through interactions.*” [4]; and **Roederer (2016)** said that “*Information-driven interactions all involve complex systems in the classical domain, with time sequences which fulfil the dictates of causality, locality, special relativity and thermodynamics. It is important to emphasize that information-driven interactions do function on the basis of force-driven interactions between their components—what counts is how these purely physical components are put together in the interaction mechanism (the ‘informational architecture’ of Walker et al.).*” [6].

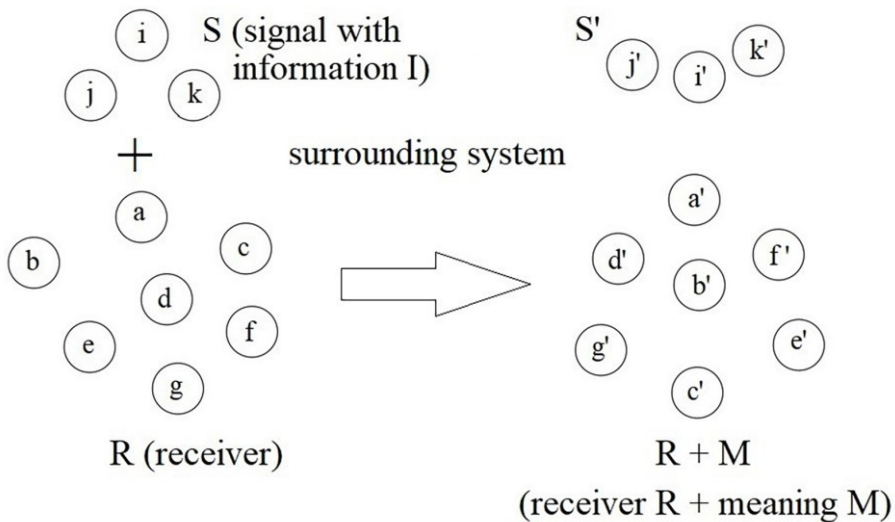
I.7 The Mechanism for Information to Mean a Certain Thing

One of the most interesting and important questions regarding information is: What is the mechanism for a piece of information to mean a certain thing to a receiver? Importantly, what is the mechanism for a piece of information to mean phenomenal qualia or phenomenal consciousness to a receiver? If we know this mechanism, we can apply it to make a machine or robot have phenomenal qualia and phenomenal consciousness in its system, and it will become conscious like us.

The answer is that, for a piece of information **I** to mean a certain thing **M** to a receiver **R**, **I** must have physical effects on **R** such that **R** changes into **R + M**; that is, **R** changes into a new physical entity that has the meaning **M** in its system. This will make all **R**’s

subsequent activities based on having **M** in its system instead of on the lack of **M** in the system. The other requirement is that these effects must be caused purely by a physical interaction cascade initiated by the interaction between **I**, **R**, and the surrounding system.

For example, please see Figure I.5. If the initial state **R** consists of a group of particles [a,b,c,d,e,f,g], with specified characteristics—such as spatial position, velocity, mass/energy, electrical charge, and spin—for [a] = a_1, a_2, a_3, a_4, a_5 , respectively, for [b] = b_1, b_2, b_3, b_4, b_5 , respectively, and so on, and if the final state **R + M** consists of a group of particles [a',b',c',d',e',f',g'], with similar specified characteristics for [a'] = $a'_1, a'_2, a'_3, a'_4, a'_5$, [b'] = $b'_1, b'_2, b'_3, b'_4, b'_5$, and so on, then for **I** to mean **M** to **R**, **I**'s particles (the particles of **I**'s carrier, to be exact) must interact with **R**'s particles such that a physical interaction cascade occurs in **R** that finally changes **R** to **R + M**, that is, changes [a]:(a_1, a_2, a_3, a_4, a_5) to [a']:($a'_1, a'_2, a'_3, a'_4, a'_5$), [b]:(b_1, b_2, b_3, b_4, b_5) to [b']:($b'_1, b'_2, b'_3, b'_4, b'_5$), and so on.



S = a signal with information I, S' = the signal after the information transfer

R = a receiver, R + M = the receiver after the information transfer

Figure I.5 The mechanism for signal **S** with information **I** to mean **M** to receiver **R**

Similarly, for an **SP** (signaling pattern) of the visual perception neural process, which is the information (**I**) of this neural process, to mean “a visual quale of a house” or “an image of a house that manifests what it looks like” (**M**) to the consciousness neural process (**R**), which supposedly consists of a group of particles [a,b,c,d,e,f,g], the following must be the case:

1. The final state of the consciousness neural process with information meaning “a visual quale of a house” in its system (**R + M**) must be able to exist. That is, the state of

$[a', b', c', d', e', f', g']$ with specified characteristics for $[a'] = a'_1, a'_2, a'_3, a'_4, a'_5$, $[b'] = b'_1, b'_2, b'_3, b'_4, b'_5$ and so on must be possible, which indeed is possible because we really can be aware of a visual quale of a house, meaning **M** can exist in **R**.

2. The SP (**I**) must have physical effects on the consciousness neural process (**R**), which consists of $[a, b, c, d, e, f, g]$, such that a physical interaction cascade occurs (in the consciousness neural process [**R**]) that finally changes the consciousness neural process (**R**) into the consciousness neural process with information that means “a visual quale of a house” (**M**) in its system, i.e., (**R** + **M**). That is, in detail, the physical cascade that occurs must finally change $[a]:(a_1, a_2, a_3, a_4, a_5)$ to $[a']:(a'_1, a'_2, a'_3, a'_4, a'_5)$, $[b]:(b_1, b_2, b_3, b_4, b_5)$ to $[b']:(b'_1, b'_2, b'_3, b'_4, b'_5)$, and so on. This process will make subsequent activities of the consciousness neural process and its connected neural processes consist of information with this meaning (**M**), rendering them able to report that the quale has occurred, remember it, create an emotion towards it, and so on.

To reiterate, as we know that qualia occur in us and have various activities about them (such as thinking, talking, and writing about them), the state of consciousness with qualia information in its system (**R** + **M**) must exist. This, in turn, means that a signaling pattern SP with information **I** that has the meaning **M** of a quale can occur and be transferred, processed, and interpreted as a quale by the consciousness process (**R**). Because the consciousness neural process interprets the information as a quale, a quale occurs in the consciousness neural process, and thus in the physical brain. This is how information can mean a quale and how a quale can occur in the physical system, the consciousness neural process of the brain. The matter is the same for a signal with information **I** meaning consciousness. In this case, the information **I** has consciousness, instead of a quale, as its meaning (**M**), but the whole interaction process proceeds similarly.

Therefore, for a machine or robot to have phenomenal qualia and phenomenal consciousness in its system or for a machine or robot to experience qualia and be conscious, a state of **R** + **M** or a state of the machine's processing system with information that means phenomenal qualia and phenomenal consciousness in its system must exist. Although, at present, we do not know whether this state is possible, if we want to make a machine or robot with phenomenal qualia and consciousness, we must assume that it is possible and strive to realize it. However, because of the requirement above, we should remember that trying to create conscious machines or robots will never succeed if we aim only for the complexity of their electronic circuits and processes but neglect this elementary fact. Essentially, the principal target must be generating information that means phenomenal qualia and consciousness in their processing systems. This can be achieved by imitating how the nervous system produces and then interprets information with such meanings.

I.8 Information: A Basic Feature of the Universe

Hence, physically and ontologically, information is not a new physical entity governed by new physical rules but is the patterns of conventional physical entities. Because conventional physical entities are governed and predictable by conventional physical laws, so is information, which is just their patterns. Thus, information is a physical entity as well, but an unconventional one. Unlike conventional physical entities, it is not composed of elementary particles—it is a pattern of them—which is why it is very different from conventional physical entities.

Because information is the pattern of a physical object and a physical object always exists in some pattern, ***a physical object always has information embodied in it***, and this fact includes every single elementary particle, as discussed in Section I.4.

Regarding physical interactions, because how all physical interactions transpire depends not only on the physical rules that govern the interactions but also on the interacting agents' characteristics, which always exist in patterns, and because patterns are information, interacting agents' information is the basis of their interactions. This is true for all physical interactions, from those between elementary particles to those between galactic clusters. Thus, fundamentally, physical interactions are information processing, and information determines all events in this universe. This has been the case since the inception of everything, and based on existing evidence, it will always be. Therefore, information is a fundamental feature of the universe.

Again, the concept that information is a basic feature of the universe is not novel; several authors have previously expressed this idea. For example, *Wheeler (1990)* pointed out that “*In short, that all things physical are information-theoretic in origin and that this is a participatory universe*” [37], and there is a concept that endorses an information-theoretic, metaphysical monism: The universe's essential nature is digital, being fundamentally composed of information as data/dedomena instead of matter or energy, with material objects as a complex secondary manifestation [3].

I.9 Remarks

It is important to bear in mind that “information” in this theory is ***a non-material thing that is transferable***. In detail, this means that it is ***a non-material thing that is transferable from one physical entity to another, consists of content, and can have physical effects on the receiver***. This type of information does not exist by itself but always in a physical entity, called a carrier. Physically and ontologically, it is the pattern of its carrier. According to this theory, the mind, qualia, and consciousness are entities that are composed of information (in certain forms). Thus, from this chapter, it should be clear to the reader that it is specifically this kind of information, and not any other kind, that the mind, qualia, and consciousness are composed of.

Extra Chapter II

Variable Qualia

When one looks at a house, listens to a song, or smells a flower, an image quale of the house, a sound quale of the song, or an odor quale of the flower appears in one's mind. Because these qualia seem unique and fascinating, some people wonder whether others experience them similarly to or differently from how they do. For example, please see Figure II.1. When people look at the same color C, is it the case that the color C qualia appear as red in some people but as blue, green, or other colors in others? Moreover, is it possible that, in some people, the color C qualia appear as some extraordinary colors that are not in the normal color spectrum that general people perceive (so the colors cannot be shown here, or even in any other pictures), such as the color represented by “!” in the figure? Despite these strange possibilities, all people will call what they see in their minds the same, “color C,” even though the manifestations of the color qualia in their minds are different (red, blue, green, etc.). Even more bizarre possibilities are that the color C qualia may appear in some people as other kinds of qualia, such as the auditory quale, olfactory quale, or the quale of an unusual percept that occurs only in some people instead of the color quale. Remarkably, despite these differences, all of them will still call what they experience in their minds the same: Color C.

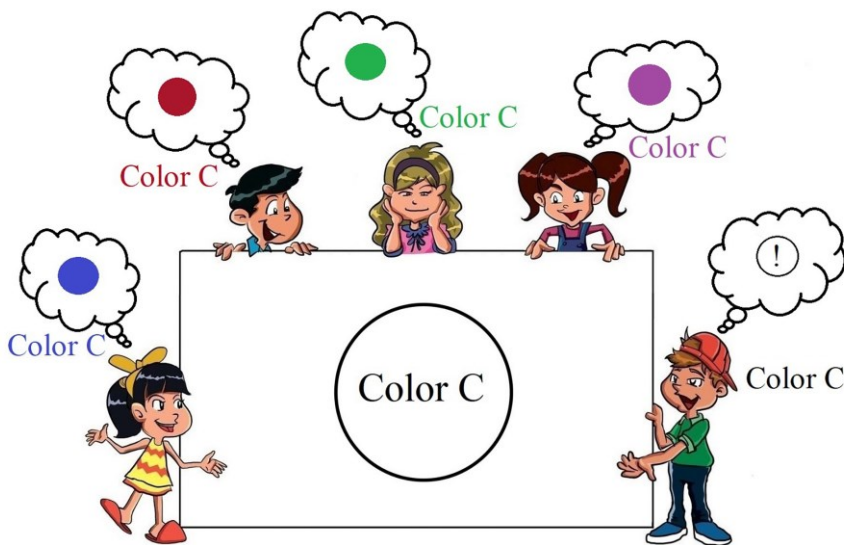


Figure II.1 Variable color qualia among people

Although philosophers have long presented and discussed this puzzle [1–3], it remains unresolved. Therefore, this chapter attempts to find solutions based on scientific evidence. It finds that there are several variations of this puzzle and that some of them have definite answers.

Variable Qualia

In this theory, qualia that manifest themselves variably, that is, manifest themselves differently in the minds of different people even though they are qualia of the same thing, are called variable qualia. Hypothetically, there can be various types of variable qualia, not just the type in the example above. Based on the causes of variability (physical vs. non-physical) and how variability occurs (randomly vs. restrictedly and completely vs. partially), they can be classified as follows:

II.1 Physically originated variable qualia

II.2 Non-physically originated variable qualia

II.2.1 Randomly variable qualia (RVQ)

- II.2.1.1 Randomly variable qualia-complete (RVQc)
- II.2.1.2 Randomly variable qualia-partial (RVQp)

II.2.2 Restrictedly variable qualia

- II.2.2.1 Inverted qualia
- II.2.2.2 Shifted qualia
- II.2.2.3 Identical-structure qualia

Now, let us investigate them to see which ones can occur and which ones cannot.

II.1 Physically Originated Variable Qualia

Physically originated variable qualia are *qualia that are variable and appear differently among people because of physical causes*.

Variability in qualia of this kind occurs because many physical factors that are involved in the processes of perception and affect the perception of neural processes, associated mental processes, and associated qualia, such as *environmental, anatomical, and physiological factors*, are different among individuals. For example, in the case of perceiving a color, *the environmental factors*, such as the illuminating light, the light's angle of incidence, the light's angle of reflection, and the intervening medium (e.g., air, water, and glass) between the color and the observer's eyes, and *the anatomy and physiology* of the whole visual perception pathway, from the corneas of the eyes to the neural circuits for visual perception, differ among people. Consequently, the resulting neural processes' and mental processes' perception and the associated perception qualia (which, according to Theorem IV, are the signaling patterns of the associated neural processes) will be different. Thus, it is highly likely that different people will consciously

experience (mentally see) the same color differently, but only slightly if their brains are normal and all physical factors are not significantly different.

The differences between physically originated variable qualia of the same object among normal people are usually small because the differences in the resulting neural processes and signaling patterns, which are qualia, are only slight. Drastic differences in physically originated variable qualia of the same thing under similar perceiving conditions in healthy people usually do not occur. This is evidenced by the fact that general people do not feel that their perception of things is very different and do not argue about it. The differences that occur are readily accepted because they are usually caused by known physical factors, such as short- or long-sightedness, low- or high-frequency hearing loss, and different thicknesses of the palm skin (which affect cutaneous sensations).

However, significant differences can occur in physically originated variable qualia if the perception systems have abnormalities or if the perceiving conditions are different. For example, color blindness can cause visual color qualia to be very different from those in normal people; gustatory (taste) qualia of the same food can be very different among people if the food they consumed immediately before had very different tastes; also, various diseases or conditions that affect sensory perception systems can cause qualia that are very different from normal, such as abnormal skin sensation perception (e.g., numbness, hyperesthesia, and paresthesia), abnormal odor perception (e.g., hyposmia, hyperosmia, and parosmia), and abnormal sound perception (e.g., hyperacusis, presbycusis, and diplacusis). Moreover, qualia that are very different from normal can result from illusions, hallucinations, and an interesting syndrome called synesthesia.

Synesthesia

Synesthesia is a condition in which a stimulus in one sensory modality, in addition to triggering the primary percept in that modality, automatically and consistently triggers a secondary, concurrent percept in another modality [4–21] or in another type of the same modality. For example, color perception occurs in addition to sound perception when people with music-color synesthesia hear musical sounds or in addition to letter or number visual perception when people with grapheme-color synesthesia see letters or numbers. Many scientists believe that synesthesia occurs because there are unusual neural connections between perception neural circuits of different modalities such that, when a perception neural circuit of one modality (such as auditory) is stimulated to function by a stimulus, another perception neural circuit of a different modality (such as visual) will function simultaneously, such as in people with music-color synesthesia. In other types of synesthesia, unusual neural mechanisms activate perception neural circuits of different types but of the same modality, such as the visual perception neural circuit of form and that of color in people with grapheme-color synesthesia [21]. Other possible underlying mechanisms for synesthesia generation include disinhibited feedback, hyperconnectivity,

hyperbinding, and enhanced white matter connectivity [19]. However, some studies have shown that synesthetic experiences (e.g., synesthetic perception of colors) are not equivalent to real perception (e.g., color perception that occurs from actually seeing colors) [22] and that the cause of synesthesia may be something else, such as a special kind of childhood memory that is recalled when there is some sensory perception occurring [23] or distributed processing of synesthetic associations [22]. However, despite uncertainty regarding the exact mechanisms that create synesthesia, it can be concluded that they are physical mechanisms involving neural connections, functions, or both.

Qualia that occur in people with synesthesia thus differ from those in general people who experience the same thing because there are two types of qualia co-occurring. Because these extra qualia occur because of physical mechanisms, qualia in these people vary from qualia in general people because of physical causes and thus are physically originated variable qualia.

II.2 Non-Physically Originated Variable Qualia

Non-physically originated variable qualia are *qualia that are variable and appear differently among people by themselves, not because of physical causes*. They can be classified as listed at the beginning of this chapter. One example of this type of variable qualia is the frequently-talked-about color qualia that can appear red in some people but blue in others (so that “your red is my blue,” as some people suspect). However, theoretically, several other types can manifest themselves variably in other ways, and some of them are interesting and illuminating. Hence, we will examine them in detail as follows:

II.2.1 Randomly variable qualia (RVQ)

Randomly variable qualia (RVQ) are *qualia that are randomly variable and appear differently in a random manner among people*. They can be subclassified into two groups depending on whether the randomness is complete or partial, as in Table II.1.

II.2.1.1 Randomly variable qualia-complete (RVQc)

Randomly variable qualia-complete (RVQc) are *qualia that are randomly variable and appear differently in a completely random manner among people*. RVQc of something will appear differently in every instance. For example, if color C qualia are RVQc, they will appear as red, blue, green, and other colors randomly at different points in the reader’s visual field (VF)—they will not appear as the same colors at all the VF points. Moreover, they will also do so in the author and other people. (Please see Row 1. RVQc in Table II.1.) Thus, the randomness is complete because the variability occurs in all cases, both in a single individual and in different individuals.

Table II.1 Manifestations of randomly variable color C qualia

	Manifest in one individual as	Manifest in several individuals as
1. RVQc	red, blue, green, and other colors	red, blue, green, and other colors in every individual
2. RVQp	a certain color	a certain color in one individual but other certain colors in other individuals

II.2.1.2 Randomly variable qualia-partial (RVQp)

Randomly variable qualia-partial (RVQp) are *qualia that are randomly variable and appear differently in a partially random manner among people*. RVQp of something will appear differently only when they occur in two or more individuals but will not appear differently in any single individual. For example, if color C qualia are RVQp, they will always appear as a certain color in an individual, such as red in the reader, blue in the author, green in another person, yellow in yet another person, and so on. However, they will not appear as red, blue, green, yellow, and other colors (as RVQc do) in any single individual. (Please see Row 2. RVQp, Table II.1). Therefore, in any one individual, they are not variable and will not appear differently; only among two or more individuals will they be variable and appear differently. Thus, they are randomly different in a partial manner because they require two or more individuals to manifest their variability.

The question is whether RVQ occur in the real world. To answer this question, we will investigate them in more detail as follows:

II.2.1.1 Randomly variable qualia-complete (RVQc)

For RVQc, there is evidence that they do not occur in the real world. Consider the following example.

A visual image that occurs in one's mind is not an all-or-none phenomenon. Instead, the entire visual image comprises millions of independent tiny visual images joined seamlessly by the visual perception neural processes. Each tiny visual image is created by a tiny perception neural process of that point in the visual field. If there is damage to some of these tiny neural processes, it will affect only the tiny images at the corresponding points in the visual field, leaving those in the unaffected part intact. For example, a lesion in the right occipital cortex can result in a defect (scotoma) at the corresponding portion of the left visual field, leaving the rest of both visual fields undisturbed. In addition, because there are separate perception neural processes for each specific characteristic (i.e., color, shape, and movement) [24,25], various types of defects can occur separately and independently. For example, a right occipitotemporal infarction

can result in achromatopsia (cerebral color blindness) in a part of the left visual field [26–29], while other visual components (i.e., shape and movement.) remain intact. Thus, the entire visual image in the mind comprises millions of independent tiny visual images, each composed of several independent types of visual characteristics.

Now, suppose one is looking at a screen of homogeneous color “C” (Figure II.2A). All the tiny neural processes for color perception must be creating the same signals—the color “C” signal—separately, and the quale for each tiny neural process must be occurring separately. If RVQc are possible, each quale of several million tiny neural processes that generate the whole image can manifest itself differently as red, blue, green, or other colors randomly, and the entire visual image may not be a homogeneous color but a mixture of myriad different-color bits (as in Figure II.2B).

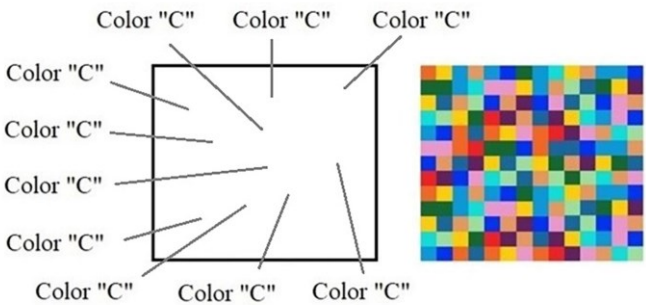


Figure II.2A

Figure II.2B

However, in reality, this does not happen. If any quale of tiny Color “C” neural processes in Figure II.3A manifests itself as red, all the others will also manifest themselves as red, and the screen will be pure red (as in Figure II.3B).

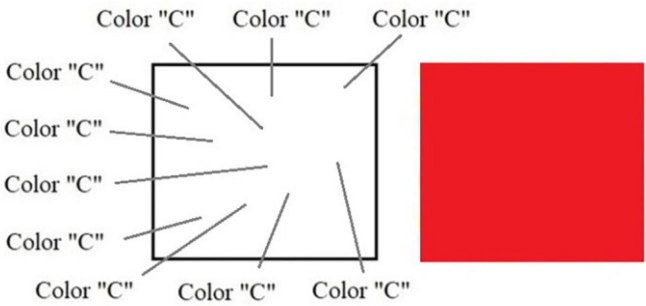


Figure II.3A

Figure II.3B

Similarly, a pair of same-color discs (such as red and red) is always perceived as a pair of same-color discs (such as red and red, as in Figure II.4A), not a pair of different-color

discs (such as red and blue, as in Figure II.4B), which can occur if RVQc are possible because the color in one disc may appear as red, while in the other, as blue.²⁷

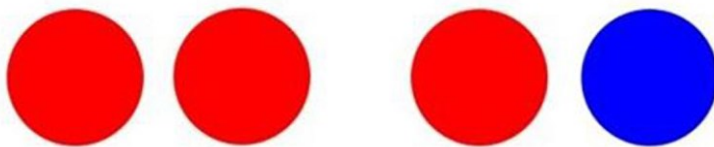


Figure II.4A

Figure II.4B

Therefore, for the same colors in the outside world, the same color qualia occur in millions of tiny neural processes, and RVQc do not occur. In addition, it never happens that color qualia occur at only some points in the visual field but that auditory, olfactory, or other kinds of qualia occur at other points in the visual field. This means qualia do not vary from visual to other types of qualia either.

Similarly, evidence indicates that the RVQc do not occur in other kinds of sensory perception either. For example, when two identical musical instruments play the same musical note, “M” (M stands for a certain musical note), the quale of the sound from each instrument will have a chance to manifest itself differently if RVQc are possible; consequently, one may appear as the piano sound of note C, while the other, the violin sound of note G. This is, of course, absurd and never happens. Everyone will hear the two sounds as the same musical note of the same musical instrument, such as the flute sound of note A if it is the flutes playing note A. The same scenario is similar for other kinds of sensory perception, such as the feeling of the same touches on both arms, the pain from the needle stabbing with similar strength on both legs, and the taste of the same honey on both sides of the tongue—the qualia of the same things on both sides are always the same, not randomly different, in any single individual.

Thus, there is no randomness in the manifestation of qualia of the same thing in any single individual. This “*no randomness in manifestation in a single individual*” of qualia has been consistently true for a long time in billions of humans everywhere nowadays and in the past—no normal person has ever reported having variable qualia occurring when perceiving a homogenous stimulus or identical stimuli. Thus, although RVQc has virtually infinite chances to manifest themselves, they have never done so. Accordingly, it can be concluded that RVQc do not occur.

²⁷ One may ask, “How do we know that the colors being compared are the same colors in the first place?” The answer is that we can know objectively, independently of our perception, whether the two or three or more colors that are being compared are the same colors by checking their radiation wavelengths with our instruments—for example, they will be found to have wavelengths of 700 nm if they are red.

It is essential to note that the non-occurrence of RVQc is evidence that qualia are physical phenomena, governed by some physical laws. If qualia are non-physical phenomena, not governed by any physical laws, there would be nothing to control their manifestations. Consequently, they would be able to appear differently in a completely random manner in all individuals, and all the strange phenomena in the discussions above would occur.

II.2.1.2 Randomly variable qualia-partial (RVQp)

However, is it possible that qualia do not appear differently in a single individual because there is only one individual's consciousness to experience the qualia? Is it the case that qualia will appear differently if there are several individuals, and thus different consciousness, to experience the qualia? As discussed before, this possible type of variable qualia is called randomly variable qualia-partial (RVQp) because it requires the presence of several individuals. Now, is there evidence that RVQp occur? The answer is that there is evidence that RVQp do not occur either.

Let us consider the case of color qualia in Figure II.5. Quale 1 and quale 2 are color qualia of two different colors (the color difference can be objectively verified by measuring their light wavelengths with some instrument).

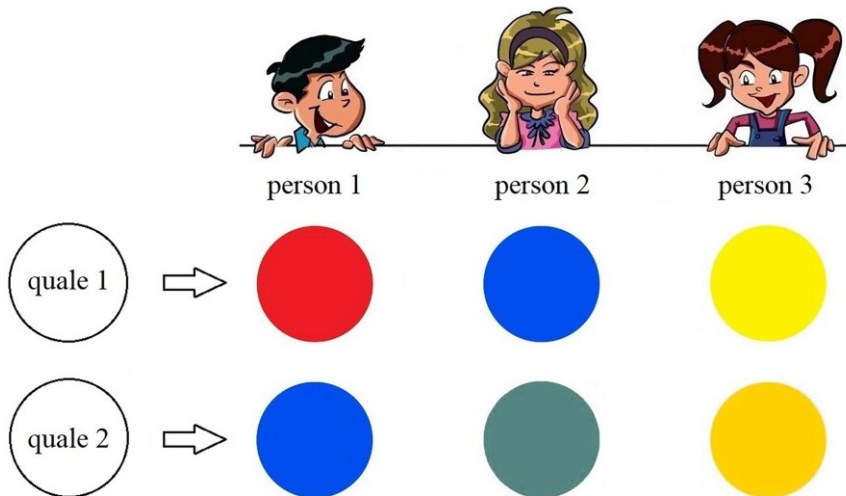


Figure II.5 Qualia 1 and 2 manifest as different color pairs in three people.

If RVQp occur, then quale 1 can randomly manifest itself in person 1 as red, person 2 as blue, and person 3 as yellow, while quale 2 can do so in person 1 as blue, person 2 as teal, and person 3 as orange-yellow. Now, please consider the upper row. This is the case of “your red is my blue” for person 2 vs. person 1 and “your red is my yellow” for person

3 vs. person 1. Next, please examine both rows for each person. Person 1 will say that qualia 1 and 2 are markedly different in hues and warmth, with quale 1 being much warmer than quale 2. Certainly, persons 2 and 3 will not agree with these remarks. Person 2 will say that the two qualia are not markedly different in their hues and warmth, and quale 1 is not warmer than quale 2, whereas person 3 will say that the two qualia are only minimally different in hues and warmth.

However, such disagreements do not occur among people with normal vision. When some people with normal vision observe a pair of certain colors to be markedly different in hues and warmth, with the first color being much warmer than the second, such as the pair of red and blue that person 1 sees, other people with normal vision will agree with these observations. This means that they (such as persons 2 and 3) see similar color pairs and not different color pairs, as shown in Figure II.5. Thus, it can be concluded that qualia 1 and 2 do not manifest themselves randomly differently in people so that different color-pairs appear in different people. This provides evidence that RVQp do not occur.

Another piece of evidence is a wheel of discs with gradually changing hues like the one in Figure II.6A. Anyone with normal color vision will agree that the hues of colors in such a wheel gradually change from one disc to another successive disc.

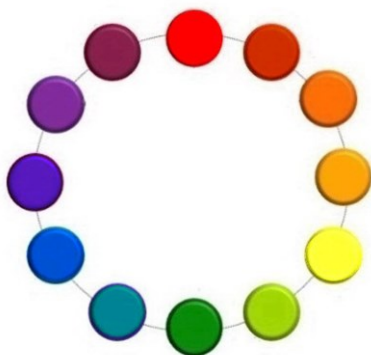


Figure II.6A

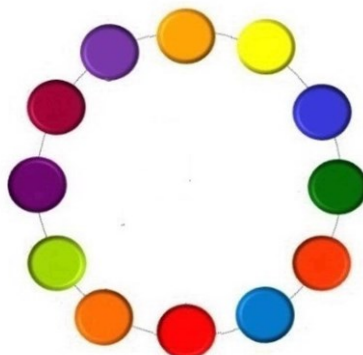


Figure II.6B

However, if RVQp occur, the color quale of each disc in the wheel will manifest itself haphazardly. For example, in some people, the red at 12 o'clock in II.6A will manifest as orange in II.6B; the yellow at 4 o'clock in II.6A, red in II.6B; and the blue at 8 o'clock in II.6A, light green in II.6B. This will result in a color wheel that has the hues of successive discs change not gradually but haphazardly, like the color wheel in Figure II.6B, in some people. But this never happens in billions of people with normal color vision. They always agree that the hues of the colors in a color wheel, like the one in Figure II.6A, gradually change from one successive disc to another. Thus, RVQp do not occur in this case either.

The evidence in auditory perception is that, if RVQp occur, the pitch qualia of musical notes must be randomly different among people. For example, some may perceive the pitch quale of a certain musical note M as the note C, some as the note F, and some as the note A[#]; and for the next sound that is one semitone higher, or note M[#], some people may perceive it as C[#], some as C^b, and others as G. These differences will make people perceive the pitch intervals between the same two notes (M and M[#]) differently. However, such dissimilar experiences do not occur in real life. Likewise, if RVQp occur, a musical scale must sound differently among people, with each note on the scale perceived differently. Consequently, a train of musical notes that have pitch qualia as C-D-E-C-E-C-E (i.e., do-re-mi-do-mi-do-mi) in some people may have pitch qualia as F-C-B-F-B-F-B (i.e., fa-do-ti-fa-ti-fa-ti) in some people and as something else in others. A train of musical notes will appear as music in some people but as chaotic sounds in others. These strange phenomena never happen, however. People agree on the orderly sounds of musical scales and music and the chaotic sounds of noise. Similarly, there are no RVQp occurrences in other kinds of sensory perception either. For example, all people perceive a series of smoothly increasing vibration or sweetness stimuli as smoothly increasing strength stimuli. It is not that some individuals perceive it as haphazardly changing strength stimuli, which can occur in some individuals if RVQp are possible.

Therefore, there is no randomness in the manifestation of qualia among individuals. This “no randomness in manifestation” of qualia has been consistently true for a long time in billions of people everywhere nowadays and in the past. Thus, although RVQp have virtually infinite chances of manifesting themselves, they never do so. Hence, it can be concluded that RVQp do not occur in the real world. Regarding the interesting hypothetical phenomenon of “your red is my blue,” although at first it seems very probable that this phenomenon can occur from variable qualia of this type—RVQp—which is a type that can manifest themselves randomly differently among different people, it has now been shown that that is not the case. RVQp do not occur and is thus not the cause of the “your red is my blue.” Therefore, if this interesting phenomenon occurs, it must arise from the variable qualia of other types, or it might not occur at all. This will be discussed in the following sections.

II.2.2 Restrictedly variable qualia

Restrictedly variable qualia are *qualia that are restrictedly variable and appear differently in restricted ways among people*.

Although there is no evidence that qualia manifest differently among people randomly, as discussed in the previous section, is it possible that they can manifest differently among people in restricted ways? For these restricted types of variable qualia, some rules restrict how they appear differently among people. For example, the rules may be that the reader’s pitch qualia are one semitone higher than the author’s but that other

characteristics of our sound qualia are the same. Such rules will result in the reader and author having similar acoustic experiences of all musical notes, chords, music, and so on. As a result, we will never be able to tell that we are experiencing different qualia. The reason why we cannot distinguish them will be discussed in detail in Section II.2.2.3. For now, this demonstrates a simple example of restrictedly variable qualia. Theoretically, there are several types of restrictedly variable qualia. Let us study some interesting types to see if they can occur among people without people knowing that they are experiencing variable qualia.

II.2.2.1 Inverted qualia

Inverted qualia are hypothetical qualia that have their manifestations, such as colors or sound pitches, inverted [1,3,30–32]. Theoretically, they exist in several forms. In the most frequently discussed form, inverted qualia exist with their non-inverted counterparts, and qualia in each group can form a spectrum with their manifestation parameters (such as the corresponding light or sound wavelengths of color or pitch qualia, respectively) arranged ordinally. If the arrangement is regularly increasing or decreasing in the parameter values, the spectrum resembles the light spectrum in the case of color qualia and resembles the chromatic scale in equal temperament in the case of pitch qualia. The inverted spectrum is equivalent to the spectrum resulting from inverting the non-inverted spectrum. If the two spectra are placed side by side with their ends aligned, each quale at every point on the inverted spectrum is the inverted quale for the quale at that same point on the non-inverted spectrum. For example, in Figure II.7, Spectrum A is the normal color-qualia spectrum, its color qualia ordinally arranged based on their corresponding light wavelengths, and Spectrum B is the inverted color-qualia spectrum, obtained from inverting Spectrum A with respect to the wavelength.

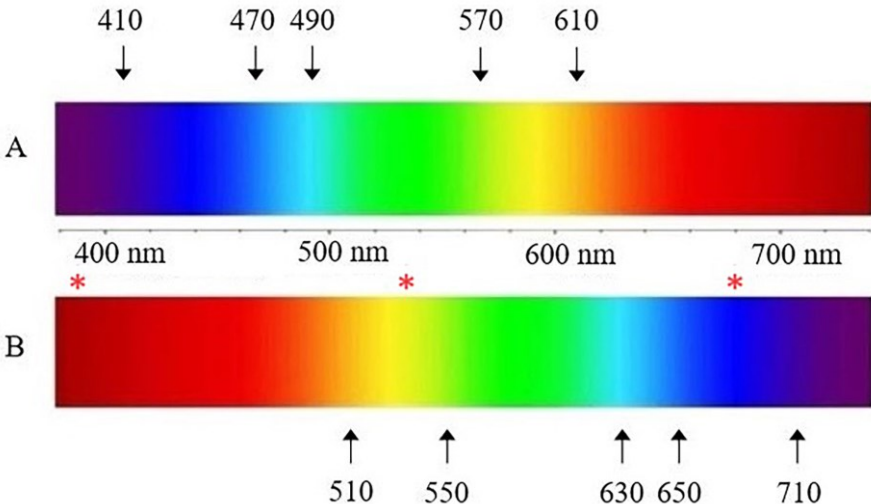


Figure II.7 A: a normal color-qualia spectrum, B: an inverted color-qualia spectrum

It can be seen that dark red, yellow, and blue in Spectrum B (marked by red stars in the figure), for instance, are inverted colors for indigo, green, and red in Spectrum A. Now, when people with normal color vision see the light spectrum, they will see it as Spectrum A. For them, they will see distinct changes in hues around wavelengths of 410, 470, 490, 570, and 610 nm. However, if color qualia appear in some people as inverted color qualia, the light spectrum will appear to those people as Spectrum B instead. Evidently, they would not agree with the previous observations. For them, distinct changes in hues are observed at wavelengths of 510, 550, 630, 650, and 710 nm. However, people with normal color vision do not disagree about the wavelengths at which the light spectrum changes hues. The lack of disagreement among people is evidence that inverted color qualia of this kind do not occur in humans.

Next, let us consider inverted pitch qualia, pitch qualia of a chromatic scale in equal temperament (Scale 1), in which C' is one octave higher than C, and its inverted counterpart (Scale 2), in which the order of all the notes is reversed, are represented as rows of musical alphabets below.

Scale 1: **C C[#] D D[#] E F F[#] G G[#] A A[#] B C'**

Scale 2: **C' B A[#] A G[#] G F[#] F E D[#] D C[#] C**

If inverted pitch qualia occur in some people, they will hear the notes in Scale 1 as those in Scale 2. For example, while people experiencing normal pitch qualia hear the 1st, 5th, and 8th notes as C, E, and G, people experiencing inverted pitch qualia will hear them as notes C', G[#], and F. Although, we cannot tell that people in both groups are experiencing different pitch qualia when they hear these individual notes because there is nothing to use as a reference for comparison, we can differentiate the two groups when they hear musical chords. This distinction is possible because the two scales have similar chords constructed from equivalent notes on each scale sound different. For example, the chord constructed from the 1st, 5th, and 8th notes (C-E-G) on Scale 1 sounds C Major, which is bright and cheerful; on the other hand, the chord constructed from the 1st, 5th, and 8th notes (C'-G[#]-F) on Scale 2 sounds F Minor, which is subdued and cheerless. This kind of difference is also the case for other chords. Consequently, similar chords constructed from the inverted scale sound different and have different aesthetic (e.g., emotional) effects from those constructed from the normal scale. If this kind of inverted pitch qualia occurs in some people, they will disagree with people who experienced the normal pitch qualia about the mood of a particular chord. However, this kind of disagreement does not occur in the real world—the same chords sound similar and have similar aesthetic effects among all people with normal hearing. This is evidenced by the fact that they do not dispute this matter. Therefore, it can be concluded that such inverted pitch qualia do not occur in individuals.

Other types of inverted qualia are possible with color qualia. In one interesting type, each inverted color quale and its corresponding normal color quale form a pair of inverted colors, which are two colors with complementary RGB (Red, Green, Blue) values that add up to 255 (the maximal RGB value). Now, when people experiencing normal color qualia see the light spectrum, they will see it as Spectrum A in Figure II.8. However, people experiencing inverted color qualia of this form will see the light spectrum as Spectrum B, any color of which is an inverted color of the color at the same wavelength on Spectrum A.

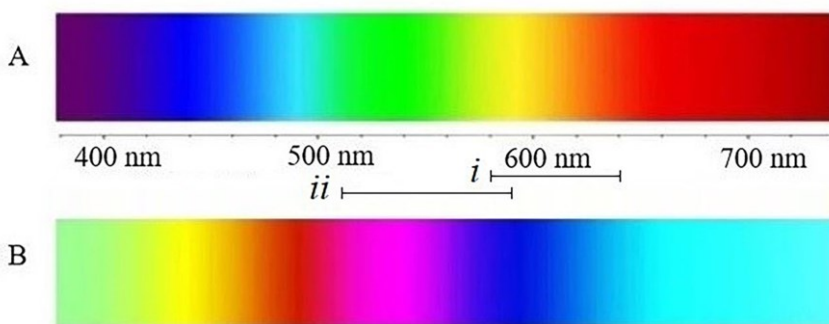


Figure II.8 The light spectrum as seen in the normal (A) and inverted (B) forms

Because the light spectrum appears to these two people groups as different spectra, they disagree on various spectral characteristics, such as, like the previous discussions for Figure II.7, where hues change markedly along their spectra. Additional examples of possible observation differences are *i*) from wavelengths 580 to 640 nm, people experiencing normal color qualia see greenish yellow changes to red, a markedly different hue, while people experiencing inverted color qualia see dark blue changes to light blue, a slightly different hue, and *ii*) from wavelengths 510 to 590 nm, people in the first group see green changes to yellow, a fairly close hue, but people in the second group see red-pink changes to dark blue, a markedly different hue. Therefore, if inverted color qualia of this type occur among people, they will be able to tell from their different observations that they are experiencing different color spectra of the same light spectrum. However, this kind of disagreement does not happen. This is evidence that inverted color qualia of this type do not occur in humans.

II.2.2.2 Shifted qualia

Shifted qualia are theoretical qualia with manifestations, such as colors or pitches, shifted up or down along their spectra relative to the non-shifted qualia. Like the first form of inverted qualia discussed above, non-shifted and shifted qualia can form spectra with their manifestation parameters (such as the corresponding light or sound frequencies) arranged ordinally. For non-shifted qualia, the spectrum resembles the light

spectrum in the case of color qualia and resembles the chromatic scale in equal temperament in the case of pitch qualia. The shifted spectrum is equivalent to the spectrum resulting from shifting the non-shifted spectrum up or down along its spectrum. If the non-shifted and shifted spectra are placed side by side with their ends aligned, each quale at every point on the shifted spectrum is the shifted quale for the quale at that same point on the non-shifted spectrum. For example, in Figure II.9, Spectrum A is the non-shifted color-qualia spectrum, its qualia ordinally arranged based on their corresponding light wavelengths, and Spectrum B is the shifted-qualia spectrum obtained from shifting Spectrum A to the left.

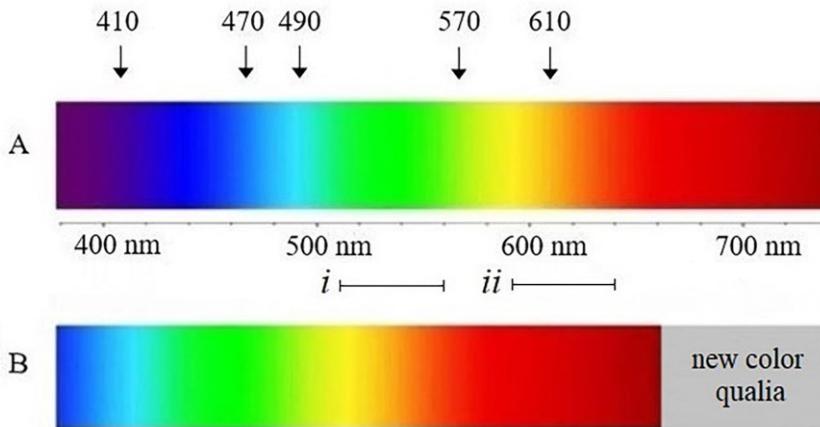


Figure II.9 Non-shifted (A) and shifted (B) color-qualia spectra

Now, when people experiencing non-shifted color qualia see the light spectrum, they will see it as Spectrum A in Figure II.9, but people experiencing shifted color qualia will see the light spectrum as Spectrum B. Although we do not know what the color qualia in the vacated portion on the right side of Spectrum B look like, we can compare qualia in the discernible portion on the left with their counterparts in Spectrum A.

Again, because the light spectrum appears to these two people groups as different spectra, they disagree on various spectral characteristics, such as, like the previous discussions for Figure II.7, where hues change markedly along their spectra. Other examples of possible observation differences are that, in the *i* (510–560 nm) interval, the hues remain almost the same for people experiencing normal color qualia but obviously change for people experiencing shifted color qualia and that, in the *ii* (590–640 nm) interval, the hues change notably for people in the normal group but continue almost unchanged for the people in the shifted group. Therefore, if shifted color qualia occur among people, they will be able to tell, based on their observations, that they are seeing different qualia spectra of the same light spectra. Yet, this kind of discrepancy does not happen. This is evidence that shifted color qualia of this form do not occur in humans.

The general relationship characteristics between normal and shifted pitch qualia are similar to those between normal and shifted color qualia. However, in the case of pitch qualia, even if pitch qualia are shifted up or down along their spectra in some people, we will not be able to tell that they are experiencing pitch qualia that are different from those we experience. This is because shifted pitch qualia have the characteristics of the next type of restrictedly variable qualia—identical-structure qualia—which enable them to occur among people without people knowing that they are experiencing variable qualia.

II.2.2.3 Identical-structure qualia

Other types of inverted or shifted qualia may occur among people; please see more discussions about this matter in Reference 1. However, one type of variable qualia that can theoretically occur in people without people being able to tell that they are experiencing variable qualia is identical-structure qualia. Identical-structure qualia come in sets. Each set occurs in a single individual and comprises qualia with manifestations, such as colors or pitches, different from their counterparts in other sets. However, all sets have identical qualia structures; that is, they have the same number and types of basic qualia components and the same spectral characteristics (please see more details about the qualia structure in PQ2.6, Chapter 4). One example of identical structure qualia is the shifted pitch qualia. Shifted pitch qualia in each set have pitches that are shifted higher or lower along their spectra relative to their counterparts in other sets. However, other sound characteristics are the same. Shifted pitch qualia in all sets have the same number and types of basic qualia components—pitch, loudness, timbre, formant, attack, sustain, decay, and release. Their spectral characteristics are also identical. For example, the identical regular repetition of the sound of each note at every doubling or halving of its sound frequency along the scale (but in different octaves) and the identical acoustic relations among notes (such as the major third, perfect fourth, and perfect fifth are consonant intervals; the minor second, major second, and tritone are dissonant intervals) are identical in all sets of shifted pitch qualia. These identities render similar chords and songs (those constructed from similar notes) among all sets of shifted pitch qualia sound the same. Consequently, all sets of shifted pitch qualia behave identically, and people would not be able to tell if they are experiencing different pitch qualia.

Next is an instructive and interesting matter. Like other variable qualia discussed previously, each set of identical-structure qualia can form a spectrum with manifestation parameters (such as frequencies or wavelengths) arranged ordinally, as discussed before. Again, for the set of normal color qualia, this spectrum resembles the light spectrum, depicted as Spectrum A in Figure II.10. Now, other sets of identical-structure color qualia consist of color qualia that we do not know what they are like. Thus, we cannot show them correctly here; we can only represent them as Spectrum B, which is arbitrarily illustrated as a gray panel, in Figure II.10.

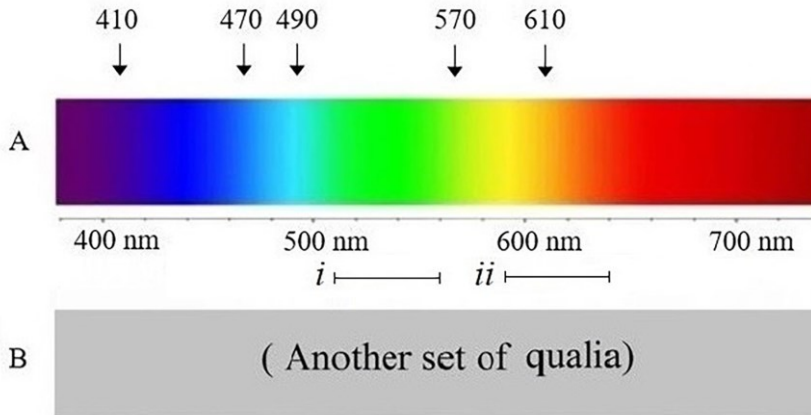


Figure II.10 Two identical-structure color-qualia spectra

The essential point is that the qualia in both spectra have the same number and types of basic qualia components: color, brightness, shape, dimension, and movement. The spectral characteristics, including all internal relationships among the qualia in each spectrum, are the same. For example, how colors change their hues along the spectrum (such as distinct changes in hues around wavelengths of 410, 470, 490, 570, and 610 nm) is the same, the apparent brightness at each wavelength along the spectrum is the same, and the perceived hue change in any interval (e.g., an indistinct hue change in the *i* interval and a clear hue change in the *ii* interval) is the same. Thus, if such identical structure color qualia occur among people, they will not be able to tell that they are experiencing different color qualia.

Regarding the puzzle of whether your red is my blue, if we both experience identical-structure qualia, it will make no difference whether that is the case because, even if your red is my blue, the spectral characteristics of the color qualia in our minds will be identical, rendering the relationships between colors in your spectrum the same as those in my spectrum. This will make every aspect of your experience of your spectrum identical to that of mine. This conclusion can be explained more clearly with an illustration as follows:

Please see Figure II.11. Suppose you experience a set of normal color qualia and I, another set of identical structure color qualia. Spectrum A will represent how you see the light spectrum, and Spectrum B will represent how I see the same light spectrum. In my spectrum, a color quale at each wavelength will be different from the corresponding one in your spectrum. Like identical-structure qualia in Spectrum B in Figure II.10, my color qualia, except blue, cannot be depicted but are represented arbitrarily by gray color.

Now, even if I see the color of the 700 nm light as blue, while you see it as red (i.e., your red is my blue), it will be that, while you see the color of the 590 nm light as yellow,

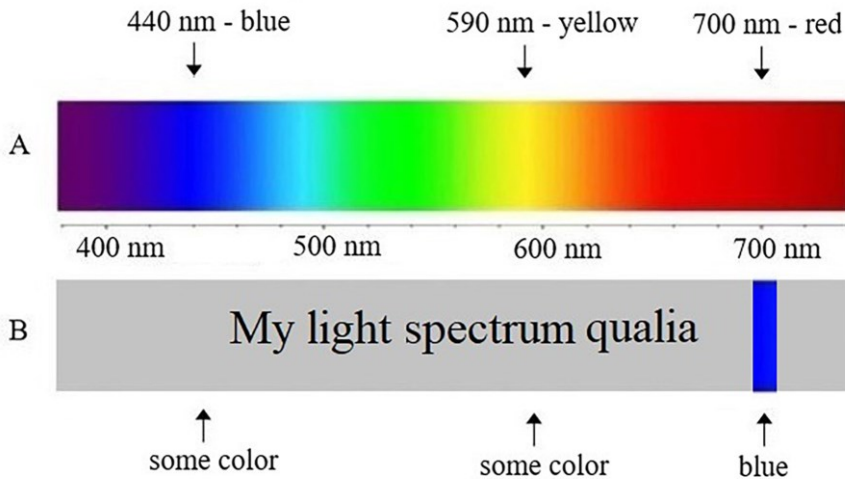


Figure II.11 Your (A) and my (B) light spectrum qualia

which is less warm than your red, I will not see it as yellow, which is warmer than my blue, but will see it as some color that is, similar to your case, less warm than my blue. We will have similar experiences with this pair of color qualia (red vs. yellow in your case and blue vs. some color in mine). What is this “some color”? The answer is that it will probably be a color that does not exist in your spectrum, even though it does in mine. Similarly, while you see the color of the 440 nm light as blue, which is much darker and cooler than your red, I will not see it as blue or back to red (which would make your blue my red); I, like you, will see it as some color that looks much darker and cooler than my blue. Again, we will have similar experiences with this pair of colors (red vs. blue in your case and blue vs. some color in mine). What is this “some color”? Once again, the answer is that it will probably be a color that does not exist in your spectrum, even though it does in mine.

Thus, it does not matter whether your red is my blue because, even if it is, my blue will relate to other colors in my spectrum exactly as your red does to other corresponding colors in yours, effectively making *my blue appear and behave as if it were red* in my spectrum. The same principle applies to all other colors in both spectra. Consequently, both spectra will provide us with identical experiences. We will perceive the two spectra identically, such as seeing hues change markedly at the same points along the spectra and observing hue differences in any wavelength interval similarly. This is true for all other identical structure qualia of any type (sound, smell, taste, etc.). Therefore, it does not matter whether identical-structure qualia occur because we will never experience them differently or be able to notice and differentiate them, and they will never have different effects on us. Our worlds will be virtually identical, even if these identical structural qualia occur.

II.3 Summary

From the current evidence, it can be concluded that, in reality,

- physically originated variable qualia can occur,
- randomly variable qualia-complete (RVQc) do not occur,
- randomly variable qualia-partial (RVQp) do not occur, and
- restrictedly variable qualia in some forms, such as inverted qualia and shifted color qualia, do not occur, but in some forms, such as identical-structure qualia, may occur, and behaviorally, people will not be able to tell that they are experiencing identical-structure qualia.

However, it is important to note that identical-structure qualia are restrictedly variable qualia—they cannot occur haphazardly but must occur in some restricted ways, with some rules governing their manifestations. The governing rules are as follows:

1. They must have different manifestations among people.
2. They must have the same number and types of basic qualia components in all people.
3. They must have the same spectral characteristics in all people.

In humans, the number and types of basic qualia components of each type of quale are fixed and differ from those of other types. For example, visual qualia always have five basic components: color, brightness, shape, dimension, and movement. In contrast, auditory qualia always have eight basic components: pitch, loudness, timbre, formant, attack, sustain, decay, and release; olfactory qualia always have two basic components: odor type and strength. Moreover, the spectral characteristics of each type of quale are different from those of other types and may be very complex and peculiar, such as the spectral characteristics of color qualia of the light spectrum, which have hues and brightness changes idiosyncratically along the spectrum, and the spectral characteristics of pitch qualia, which have similar sounds repeated in different octaves regularly at every doubling frequency. Therefore, if identical-structure qualia do occur, the physical problem about them will be: What is the mechanism that makes those qualia manifest themselves *differently* among different people yet at the same time manifest themselves *restrictedly correctly* so that they have not only the *same number and types of basic components* but also the *same unique spectral characteristics* of that type of quale among billions of different individuals at different places and different times? And the philosophical question about them will be: Why should qualia manifest themselves differently only in some restricted ways, why not in a totally random way, as RVQc do, or why not “not differently” at all?

II.4 Remarks

Theoretically, because the signaling patterns of perception neural processes in different people perceiving the same things under the same conditions are similar and because, according to Theorem IV, those signaling patterns are qualia, qualia (of the same things) in different people are similar. Therefore, according to this theorem, all variable qualia that are not physically originated do not occur. These are the predictions of this theory. Please see their details in Section 10.1.

Extra Chapter III

P-zombie

In our daily lives, we talk, work, play, and engage in various other activities with other people all the time. Most of us probably do not think about whether they experience the world as we do because they behave very similarly to us. Therefore, it seems reasonable to assume that they are like us internally. Still, some people suspect that that is not the case. They conceive that, while we see things around us, listen to songs, smell flowers, and enjoy their lively images, beautiful sounds, or sweet smells, other people may not have these vibrant phenomena occurring in their minds when they experience the same things. That is, while we are living in a world of dazzling phenomena, other people may be living in a dark, phenomenon-less world. The question is whether this surmise is valid.

These vibrant phenomena we experience in our minds are called qualia, and the awareness and experiences of what they are like (such as awareness and experiences of what colorful images, melodic sounds, or sweet smells are like) are called conscious awareness and experiences, or consciousness. This chapter examines whether there can be beings without qualia and consciousness but can live and behave exactly like us or be physically identical to us, who have qualia and consciousness, and whether there are such beings living among us or some people around us are such beings.

III.1 Philosophical Zombie

In philosophy, such a being is called a philosophical zombie or a p-zombie, which is defined as “*a being that is physically identical to a human but lacks qualia and consciousness*” [1–23]. This concept likely originated from some people’s notion that qualia and consciousness do not have physical effects; therefore, lacking them would not result in physical differences. In real life, when we observe people going about their activities, we can truly doubt the role of qualia and consciousness. It is not apparent that they assist us in our activities, so it is not illogical to believe we can continue doing everything normally without them. This idea gains further support in the present world when we witness computers, robots, and various automated machines efficiently performing diverse tasks despite lacking qualia and consciousness. Accordingly, qualia and consciousness may be unnecessary, and some argue that we can live and function as usual without them.

However, for the above definition to be valid, qualia and consciousness must not have physical effects. Otherwise, the definition defines some being lacking something with physical effects as physically identical to another being having that something, which is

not possible. Also, if qualia and consciousness have physical effects, the definition defines a certain being lacking qualia and consciousness as having their effects, which is also impossible. This discrepancy in the definition occurs because the definition defines a being as lacking only qualia and consciousness but otherwise physically identical to a human, meaning the defined entity still possesses qualia and consciousness effects as the human does. Overall, if qualia and consciousness have physical effects, the definition defines a physically impossible being. This problem becomes more evident when we consider it in the form of equations and a picture, as follows:

(In the following discussions and picture, Q & C = qualia and consciousness, QCE = qualia's and consciousness's physical effects, MA = mental activities, "+" = "with," and "-" = "minus")

A human = a being + Q & C + QCE + other MAs ... (1)

A p-zombie = a human – Q & C ... (2) (by definition)

= a being + QCE + other MAs ... (3) ... [from (1) and (2)]

The definition defines a p-zombie as physically identical to a human.

A p-zombie $\equiv$ **A human** ... (4)

a being + QCE + other MAs $\equiv$ a being + Q & C + QCE + other MAs ... (4')

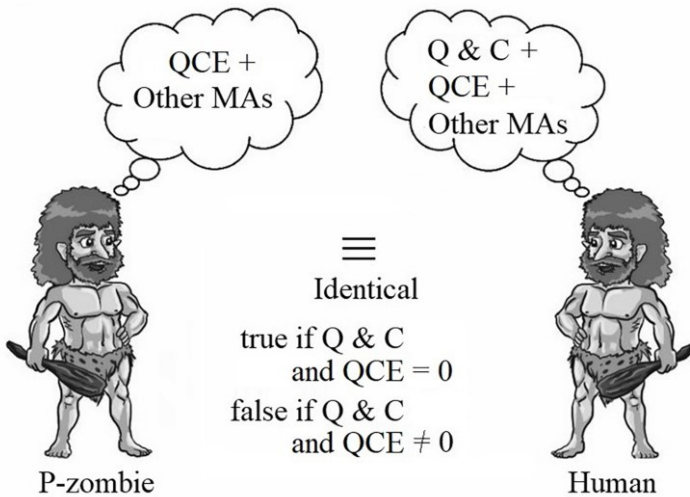


Figure III.1 P-zombie: physically identical to a human but lacking Q & C

It is obvious that if Q & C do not have physical effects, both Q & C and QCE will be physically null (= 0). Hence, (3) will define a physically possible entity, and (4) and (4') will be true. Accordingly, a p-zombie will be a physically possible entity and thus can

exist physically. On the contrary, if Q & C have physical effects, both Q & C and QCE will not be physically null. Accordingly, (3) will define a physically impossible entity (a being with QCE but lacking Q & C is physically impossible), and (4) and (4') will be physically invalid (defining a physically impossible entity, as just discussed, to be physically identical to a real physical entity, a human, is physically invalid). Therefore, a crucial question is *whether Q & C have physical effects or not*.

The answer is affirmative. This matter has been analyzed in detail in Chapters 5 and 7, and it has been demonstrated that Q & C have physical effects. They have physical effects simply because they induce the brain to create awareness and experiences of themselves. Evidently, we are aware of and experience their occurrences and what they are like:

Qualia → awareness and experiences of their occurrences and of what they are like.

Consciousness → awareness and experiences of its occurrence and of what it is like.

Because all awareness and experiences require specific neural processes to function for their occurrences—they cannot occur alone (Theorem I)—qualia and consciousness must induce functions of certain neural processes. As neural process functions are physical, qualia and consciousness induce certain physical functions. Thus, they have physical effects, and these effects are their earliest physical effects. Other physical effects subsequently follow and are numerous. For example, we think about, talk about, have conferences on, conduct research on, and write articles and books about them; even the reader is reading an article about them right now. None of these physical activities would occur if qualia and consciousness had no physical effects.

Therefore, because qualia and consciousness have physical effects, both Q & C and QCE are not physically null. This has two critical consequences:

1. A being lacking Q & C cannot be physically identical to a being with Q & C. Yet a p-zombie is defined as lacking Q & C but identical to a human (a being with Q & C), which is not physically possible. Thus, a being defined by this definition is not a physically possible entity.

2. Also, since a p-zombie is defined as lacking Q & C but otherwise identical to a human, which is a being with QCE, it must also have QCE like a human. However, having QCE without Q & C is physically impossible. In this aspect, the definition also defines a physically impossible entity.

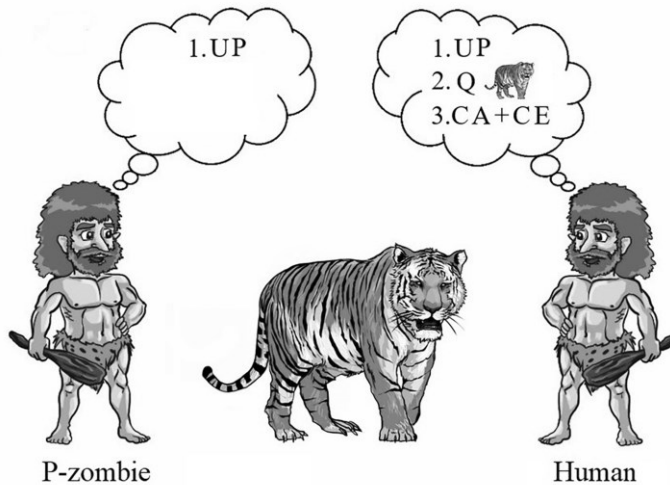
Summarily, a p-zombie defined by this definition is an impossible physical entity and, although it can exist imaginarily, cannot exist physically. There cannot be such p-zombies among us, nor can some of us be p-zombies. Likewise, the conjecture that, while we live in a world of dazzling phenomena, some other people live in a dark, phenomenon-less world yet can behave like us is false.

III.2 Physical Zombie

Let us define a new p-zombie, a physical zombie, as a human who lacks only qualia, consciousness, and their physical effects. Theoretically, this can be caused by a disease or condition that selectively affects the neural processes involved in the qualia and consciousness generation without affecting other brain parts, such as a limited cerebral infarction in the areas of these neural processes.

Obviously, from this definition, this p-zombie cannot be physically identical to a human because it is a being lacking some physical things a human has. However, everything else (which is not qualia, consciousness, or their effects) in the p-zombie is the same as that in a human. Because the definition does not require a p-zombie to be physically identical to a human, there is no contradiction in the definition. Therefore, a p-zombie defined by this definition is a possible entity and can physically exist. Indeed, there exists a real physical zombie in the medical literature. A patient with a stroke lost conscious color perception but still had unconscious color perception: He was able to describe the colors of objects correctly above chance to some degree, even though he denied perceiving those colors and did not have the color qualia [24].

Now, let us study what happens in a p-zombie and a human when they see a tiger (Figure III.2).



UP = unconscious perception, *Q* = image quale of the tiger
CA = conscious awareness of *Q*, *CE* = conscious experience of *Q*

Figure III.2 P-zombie's perception vs. human's perception

The early neural events in the visual pathways from the eyes to the cortical areas immediately before the cortical areas for visual perception are the same. However, after

the perception areas begin to function, the events differ. In the p-zombie, there is an unconscious visual perception of the tiger (1. UP), but this occurs without a quale, conscious awareness, or a conscious experience, similar to image registration and other related electronic operations of an image on the motherboard of a present-day computer. In the human, in addition to unconscious perception (1. UP), similar to that in p-zombie, a visual quale of the tiger (2. Q) occurs. After this, conscious awareness and experience (3. CA + CE) of the quale occur. Subsequently, conscious awareness and experience of *the conscious awareness and conscious experience of the quale* also occur. Conscious awareness and conscious experiences, like other mental processes, require specific neural processes for them to occur; they cannot occur alone by themselves (Theorem I). Therefore, additional neural processes that do not occur in the p-zombie occur in the human. These additional neural processes, being physical, must have physical effects that do not occur in the p-zombie. However, although we know some of their physical effects, as just discussed above, we still do not know precisely what other effects are. They may cause more intense fear, alertness, and sympathetic stimulation. However, their final behavioral effects are obvious and numerous, as mentioned near the end of Section III.1. Thus, it is definite that the human is physically and behaviorally different from the p-zombie. Hence, the human world is physically and behaviorally different from that of p-zombies. Moreover, it can be concluded generally that a world without qualia or consciousness is physically and behaviorally different from a world with them.

This matter can be more obvious if we consider it in the opposite way. A present-day computer certainly does not have conscious awareness or experiences of any quale that may occur in it. This is because conscious awareness and a conscious experience of a quale are additional functions with additional information, which need additional circuits, software, or both to operate the new functions and manage the added information. However, at present, there are neither circuits nor software in the computer to operate these novel functions and manage the extra information because we, their creators, do not build such circuits and software for it as we, at present, simply do not know how to do so. Therefore, a computer that can function to have conscious awareness and conscious experiences of qualia must have additional circuits, software, or both. Thus, it will be physically and functionally different from computers that perform other functions similarly but cannot function to have conscious awareness and conscious experiences of qualia. (More detailed discussions of this matter are provided in Chapter 9, Section 9.3.1: Do computers and robots have qualia and consciousness?)

III.3 Remarks

In conclusion, since qualia and consciousness have physical effects, philosophical and physical zombies, defined as lacking qualia and consciousness, cannot be physically identical to humans, who possess both. However, philosophical zombies are also defined as being physically identical to humans, which is impossible, and as having the effects of

Extra Chapter III

qualia and consciousness, which is also impossible. Hence, they are physically impossible entities and cannot exist physically. On the other hand, physical zombies are not defined as being physically identical to humans or as possessing qualia's and consciousness's effects. They are thus physically possible entities and can exist physically.

Conclusions

Based on the physical properties of the mind, qualia, and consciousness and the current scientific evidence, it can be concluded that:

I. The mind coexists with the brain (Theorem I); it is the composite of all neural information-processing processes (Theorem II). Since neural information-processing processes are inherent in the brain, the mind is as well, and no novel entity emerges to be the mind. Because information-processing processes have physical effects, the mind has physical effects.

II. Qualia are physical phenomena (Theorem III); they are the signaling patterns of some neural processes (Theorem IV). Specifically, they are signaling patterns of a special kind, Special Signaling Patterns (SSPs), which are information that means phenomena manifesting what themselves are like, such as an image of a house, a sound of a song, and an odor of a flower, to the consciousness neural process. When some neural processes produce SSPs and these SSPs are read by the consciousness neural process, they are interpreted as such, and phenomena manifesting what themselves are like, such as an image of a house, a sound of a song, and an odor of a flower, naturally and inevitably appear in the consciousness neural process and the brain. Since signaling patterns are inherent in neural processes, qualia are as well, and no novel entities emerge to be qualia. Further, because signaling patterns physically affect neural processes that read them, qualia have physical effects.

III. Consciousness is the signaling state of a neural process called “consciousness neural process” (Theorem V). Specifically, it is a composite of signaling states of a special kind, Special Signaling States (SSSs), which is information that means awareness and experiences of what qualia are like, such as awareness and experiences of what an image of a house, a sound of a song, and an odor of a flower are like, to the consciousness neural process itself. When the consciousness neural process produces this signaling state and this signaling state is read by the consciousness neural process by reentrant signaling, it is interpreted as such, and awareness and experiences of what qualia are like, such as awareness and experiences of what an image of a house, a sound of a song, and an odor of a flower are like, naturally and inevitably appear in the consciousness neural process and the brain. Since a signaling state is inherent in a neural process, consciousness is as well, and no novel entity emerges to be consciousness. Furthermore, because a signaling state physically affects its own and connected neural processes, consciousness has physical effects.

IV. Based on Theorem II and Theorem IV, the following can be concluded:

Conclusions

- Similar neural processes have similar mental processes and qualia.
(Theorem VI)
- Different neural processes have different mental processes and qualia.
(Theorem VII)
- Similar mental processes and qualia require similar neural processes.
(Theorem VIII)
- Different mental processes and qualia require different neural processes.
(Theorem IX)

V. From scientific evidence, it can be concluded that mental interactions are physical interactions. (Theorem X)

For the problem of qualia that can manifest themselves differently in different people, or variable qualia, such as color qualia that can appear as red in the reader but as blue in the author and as other colors in other people, it can be shown that some types of them occur, but others do not. Ultimately, it does not matter whether the author's blue is the reader's red because, even if it is, the author's blue will behave in all aspects as if it is red in the author's mind, and vice versa for the reader. We will experience them similarly and never encounter different effects from them.

For the problem of a p-zombie, because qualia and consciousness have physical effects, a being without qualia and consciousness cannot be physically identical to a being with them. Since a p-zombie is defined as "a being that is physically identical to a human but lacks qualia and consciousness," its definition defines something physically impossible. Hence, a p-zombie is a physically impossible entity and, although it can exist imaginarily, cannot exist physically. We exist physically; none of us are p-zombies.

For the main subject of this theory, from Theorems I, II, IV, and V, it can be concluded that the mind, qualia, and consciousness are informational entities that coexist with neural processes and the brain. Being informational entities, they are categorically different from conventional physical entities, such as mass, energy, and force, which are called mechanical entities in this theory.

It can also be concluded that there are two fundamentally different classes of entities in this universe: the mechanical class and the informational class. The former comprises elementary particles and their interactions, which combine to form mechanical entities—namely, all material things, energy, forces, and other complex mechanical entities, such as the brain, neural circuits, and electronic circuits. The latter comprises information and information processing, which combine to form informational entities—such as the mind, mental processes, qualia, consciousness, and electronic information-processing processes. The two classes are inherently and inseparably connected and function unitedly as one. They are the two sides, the mechanical and the informational sides, of the same thing and

are counterparts of each other. It is the nature of this universe that there exist not one but two sides to everything.

Basically, the mind, qualia, and consciousness exist in this universe because it is fundamental to its nature that these entities exist. Fundamentally, some kinds of physical processes—neural information-processing processes—can be the mind; some kinds of signaling patterns—special signaling patterns—can be qualia; and some kinds of signaling states—special signaling states—can be consciousness. By these fundamentals, “we”—the mind, qualia, and consciousness—exist in this universe. It is a brute fact. This basic principle is the scientific answer to one of the most essential questions of our lives: How is it possible that “we” exist?

It can also be concluded that the mind, mental processes, qualia, and consciousness did not exist at the beginning of the universe or the beginning of life. Information in these primordial times was not advanced enough to be them. They began to appear when the universe evolved to the stage with complex structures capable of forming complex enough information. One such structure is the nervous system. Once there was a nervous system—a system with neural information-processing processes—the mind began to appear. Once the nervous system evolved to the stage with neural processes capable of forming special signaling patterns and special signaling states, qualia and consciousness began to occur. The fact that the mind, qualia, and consciousness still exist today after appearing in this world hundreds of millions of years ago indicates that they have been preserved in the evolutionary process, implying that they yield some survival advantages to the species possessing them. Thus, they still exist because they somehow help increase the survival chances of the species that possess them. This is the scientific answer to one part of the hard question of qualia and consciousness and to another basic question of our lives: Why do “we”—the mind, qualia, and consciousness—exist?

It can thus be concluded that qualia and consciousness are not novel entities emerging out of nothing. They are evolved entities from the already existing entity: information. Additionally, it can be concluded that qualia and consciousness do not exist in everything but exist only in entities capable of forming complex enough information—animals with advanced nervous systems. Hence, qualia and consciousness neither exist in everything nor always exist. On the other hand, one entity that exists in everything and always exists is information.

When viewed from the third-person point of view, the point of view we have when thinking about or investigating it, information that means qualia or consciousness does not appear as qualia or consciousness because it is only looked at (mentally or physically), not read nor interpreted. However, when read from the first-person point of view, the natural point of view of functioning neural processes, it is interpreted according to its meaning. Consequently, qualia or consciousness naturally and inevitably appears in the reading neural processes and the brain. This combined point-of-view and information-

Conclusions

interpretation concept scientifically answers the other part of the hard problem and the explanatory gap of how phenomenal qualia and consciousness can appear in the brain.

As remarked in the previous edition, this theory is a basic theory that deals with basic concepts of the nature of the mind, mental processes, qualia, and consciousness. It is merely one step in unraveling this great puzzle. There are still numerous problems to be solved to understand them completely. Some of them are as follows:

Technical problems: What are the exact characteristics of neural circuits and neural processes that can produce qualia and consciousness? What are the exact characteristics of the signaling patterns that are qualia and of the signaling states that are consciousness? Which exact part of the signaling is qualia and consciousness—the synaptic transmission; the signal propagation along the axons, dendrites, and soma; or the whole signaling process?

Fundamental problems: Can Theorems I and II be extended to cover minds in other groups, not just the group of animals with a nervous system? From the properties of signaling patterns and signaling states, can we predict the characteristics that make signaling patterns and states become qualia and consciousness, respectively? Can some forms of signaling in other systems, such as electronic systems, be qualia and consciousness?

Final problems: As information inherently exists in all physical entities and as all physical interactions fundamentally are information processing, information and information processing are intrinsic in all physical entities and interactions and have pervaded this universe entirely since its initiation (Extra Chapter I: Information). However, since information is the pattern of its carrier and a pattern depends on its boundaries, which are human-created distinctions, is information considered isolated in each entity just a human-made construct? Are we—our minds and consciousness—which are viewed as individual informational entities, artificial distinctions? Because no true boundaries exist, are we—our minds and consciousness—and all other things, including others' minds and consciousness, basically connected all the time and part of one whole? Is the ancient concept of panpsychism scientifically and fundamentally correct? Is it only that what it refers to as omnipresent may not be the mind or consciousness but rather the deepest and most fundamental entity: information? Can this concept be empirically investigated so that we will finally achieve the ultimate understanding of this aspect of nature?

Thus, as noted in the first edition, there are many questions that this theory does not answer. However, the author hopes that this theory, even though incomplete and potentially flawed, can provide new concepts, offer new directions for investigating this great problem in science, and help lead to the complete theory of the mind.

Glossary

Brain: a material organ that can evidently execute the three activities, including the highest-level ones of that animal, for the whole animal and is composed of material components and all their physical activities. (Page 13)

Conscious awareness: awareness of what a quale is like. (Page 62)

Conscious experience: experience of what a quale is like. (Page 62)

Consciously experienceable: A mental phenomenon is consciously experienceable if the mind can be aware of and experience what that phenomenon is like.

(Equivalently): A mental phenomenon is consciously experienceable if awareness and an experience of what that phenomenon is like can occur in the mind. (Page 55)

Consciousness: the composite of all conscious awareness and conscious experiences.

(Equivalently): the composite of all awareness and experiences of what qualia are like.

(Equivalently): the composite of awareness and experiences of what things in the outside world are like in their various representations.

(Concisely): the awareness and experiences of what things are like.

(Page 107)

Consciousness mental process: the mental process that functions to be consciously aware of and consciously experience mental phenomena.

(Equivalently): the mental process that functions to create conscious awareness and conscious experiences, or consciousness. (Page 107)

Consciousness neural circuit: the neural circuit that exists and functions with the consciousness mental process and produces consciousness. (Page 121)

Consciousness neural process: the signal-processing process of the consciousness neural circuit, which produces consciousness. (Page 121)

Conventional physical entity: an entity that is composed of elementary particles and their interactions. (Page 51)

Electrical/electrochemical-signal-processing process: a process that processes material electrical/electrochemical signals. (Page 43)

Explanatory gap: the problem of how phenomenal qualia and consciousness can arise from material, phenomenon-less physical systems, such as neural processes and the brain. (Page 140)

Extended mind: a mind with all mental processes, including those in the brain, spinal cord, and peripheral, autonomic, and enteric nervous systems. (Page 33)

External world: the world that includes everything except the mind and the place where it resides (the neural processes). (Page 24)

Hard problem (of consciousness and qualia): the problem of why and how qualia and consciousness occur. (Page 157)

Ineffable: indescribable. (Page 59)

Information: a non-material thing that is transferable. (Pages 16 and 182)
(The full definition): a non-material thing that is transferable from one physical entity to another, consists of content, and can have physical effects on the receiver. (Page 184)

Information-processing process: a process that processes information. (Page 43)

Informational entity: a non-material entity that is composed of information and information processing. (Pages 47 and 51)

Mechanical entity: an entity that is composed of elementary particles and their interactions. (Page 51)

Mental phenomenon (mental process phenomenon): the product of a mental process. (Page 13)

Mental process: a mind's component that performs any of the three activities. (Page 13)

Mind: a non-material entity that exists in an animal with a nervous system and can evidently execute the three activities, including the highest-level ones of that animal, for the whole animal. (Page 12)

Neural circuit: a group of neurons that are connected in a specific pattern to perform the neural circuit's principal function, which is to process signals for a certain operation. (Page 13)

Neural process: the signal-processing process of a neural circuit. (Page 14)

Outside world: the world that includes everything except the mind and the place where it resides (the neural processes). (Page 24)

Phenomenal characteristic or phenomenality: the characteristic of manifesting what the quale (of something) is like in the mind. (Page 58)

Phenomenal consciousness: another equivalent term for consciousness. (Page 108)

Phenomenal quale (qualia): another equivalent term of quale (qualia). (Page 58)

Phenomenal manifestation: a manifestation of what the quale (of something) is like in the mind. (Page 58)

Phenomenality-less or phenomenon-less: without phenomenality. (Page 87)

Philosophical zombie (p-zombie): a being that is physically identical to a human but lacks qualia and consciousness. (Page 217)

Quale (qualia): a mental phenomenon that is consciously experienceable. (Page 57)
(Equivalently): a mental phenomenon that manifests what itself is like in the mind.
(Equivalently): a mental phenomenon that exhibits a phenomenal manifestation.
(Page 58)

Signaling pattern: the pattern of signaling that a neural circuit sends to another neural circuit to convey information. (Page 15)

Signaling state: the pattern of signaling of a whole neural circuit, with signals circulating in the circuit in a particular pattern at a certain moment. (Page 16)

Special signaling pattern: a neural process's signaling pattern that can induce conscious awareness and a conscious experience of itself in the consciousness neural process. (Page 95)

Special signaling state: a reentrant signaling state with information that means conscious awareness and a conscious experience to the consciousness neural process. (Page 129)

Subjective experience: another term for conscious experience. (Page 63)

The three activities: the activities that include

- i. sensing signals from outside the body, from the body parts, and from within the mind,
 - ii. acting on signals, resulting in various mental processes, and
 - iii. sending signals between the mental parts and to the effectors of the body.
- (Page 12)

Unconscious awareness: awareness of something without being aware of what that thing is like. (Page 65)

Unconsciously aware of: the mind is unconsciously aware of something if it is aware of that thing without being aware of what that thing is like. (Page 65)

Variable qualia: qualia that manifest themselves variably—manifesting themselves differently in the minds of different people—even though they are qualia of the same thing. (Pages 198 and 199)

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Chapter 1

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Like many other children, when I was a child, I wondered about many things, especially the universe. Does this universe have a boundary, or is it boundless? If the boundary exists, what does it look like, and what is beyond it? If not, how can the universe go on infinitely? Are the space and time continuous or composed of very thin slices in succession? If so, how thin is each slice? How did the universe begin, and what was it like before that? When it ends, what will it be like after that? And many other questions. I dreamed of being a scientist in physics or astronomy to learn more about these matters and find more answers. However, because of various factors, I did not become a scientist but came to be a doctor and, finally, a neurologist instead.

That was not a wrong choice because it finally helped me answer the deep, non-physical questions I have always had in my mind since I was a child: What is the mind? What are these fascinating phenomena—visions, sounds, smells, emotions, thoughts, and others—I experience every day in my life? Do other people experience them—see them, hear them, smell them, and so on—as I do? Or is what they experience in their minds different? Why can't there be just the mind without them? Of what uses are they? How can the universe this vast exist and transpire as I experience it in the brain this small? And many other questions, including the most important ones: What am I, and why do I exist?

During more than 37 years of my clinical practice, I have seen tens of thousands of neurological and psychiatric patients with various disorders in perception, movement, behavior, emotion, consciousness, and other neurological functions. I have seen patients ranging from perfectly calm to dangerously delirious to deeply comatose, from very brilliant to severely demented, and from in perfect health to at death's door; some even passed through it temporarily, but some, forever. I have had the chances to treat them with my own hands, some with success but some with failure. I have seen them change with my own eyes, some for the better but some for the worse. Bit by bit and year after year, I have learned and got clues from these encounters. Finally, all these experiences have given me the key to the nature of the mind and its phenomena—qualia, consciousness, and others—and enabled me to write this theory.

Dr. Chirapat Ukachoke

June 10, 2024

***“Since I was a child, I have always wondered ... what I am,
why there must be me, and why there have to be such
special phenomena as the red color, the happy emotion, and
the feeling of what it is like to be me in my mind ...***

The answers had eluded me all along.

Finally, after a very long time of puzzlement ...

***Thirty-seven years of seeing neurological and psychiatric
patients has given me the key to unravel these mysteries.”***

*In the end,
it can be concluded that we—minds, qualia, and
consciousness—are informational entities on the
informational side of the universe.*

*We feel information ... ourselves... phenomenally
because we do not look at it from the outside
but experience it from the inside.*

*We are here because it is fundamentally possible
to have us in this universe and because we help
increase the survival chances of our species
... and ourselves.*

*You are here to help increase the survival chances
of your species
... and yourself.*

