FRACTAL COGNITIVE TRIAD: THE THEORETICAL CONNECTION BETWEEN SUBJECTIVE EXPERIENCE AND NEURAL OSCILLATIONS

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ABSTRACT: It has long been appreciated that the brain is oscillatory[1]. Early measurements of brain electrophysiology revealed rhythmic synchronization unifying large swaths of the brain. The study of neural oscillation has enveloped cognitive neuroscience and neural systems. The traditional belief that oscillations are epiphenomenal of neuron spiking is being challenged by intracellular oscillations and the theoretical backing that oscillatory activity is fundamental to physics. Subjective experience oscillates at three particular frequency bands in a cognitive triad: perception at 5 Hz (exogenous), action at 2 Hz (endogenous), and attention at 0.1 Hz (cognitive). This triad functions as a means of information flow across scales of magnitude in a biological fractal. The *Homunculus Solution* is proposed in which mental experience occurs at fixed scales of biology. The mind is composed of minds, perceived as "the voices in your head." Each voice has voices inside its head to increasingly microscopic scales, forming an interactive fractal of subjective experience.

KEYWORDS: Oscillations; Cognition; Fractal; Homunculus; Emergence; Submergence

NEURON AS HARMONIC OSCILLATOR

Pioneer neuroscientist Camillo Golgi believed that the fundamental unit of neural function was the syncytium, or diffuse nerve network[2]. Golgi's theory was trumped by his contemporary, Santiago Ramón y Cajal, who proposed the "neuron doctrine," which relies on individual neurons acting independently to integrate inputs via chemical synapses. The syncytium theory, or network doctrine, is seeing a comeback by augmenting the neuron doctrine to include traveling waveforms of electrical activity[3].

When two neurons wish to communicate, via chemical signals, they must also synchronize electromagnetic fields[4]. The traditional view is that a neuron produces an action potential, or burst of electrical activity leading to neurotransmitter release; then, the receptive neuron reacts to these chemicals and produces an electrical signal. This picture is complicated by the surrounding electromagnetic fields that will increase or decrease the sensitivity of the neuron. If two neurons are coupled in frequency and aligned in phase, then signals sent during peak strength in local field potential will be maximally received. During the downswing, signals will be rendered ineffective. Pascal Fries coined the term windows of coherence and demonstrates that this principle is used to synchronize specific neurons and ignore others[5].

Let us consider an example: A region of the frontal cortex directs attention to the left visual field. It synchronizes its oscillating local field potential with the region of the visual cortex that has information relevant to the left visual field. The visual cortex corresponding to the right visual field provides only distracting information; as a result, the frontal cortex desynchronizes with these neurons to reduce susceptibility to distraction. This effectively induces an attentional bias to the left visual field in the frontal cortex in order to orchestrate the appropriate behavioral response.

Oscillations can be generated by two neurons inhibiting each other. Say neuron A fires and inhibits neuron B; then, neuron B inhibits neuron A[6]. This induces oscillation based on synaptic activity. Over time, neurons will tend to reach chaotic attractor states based on the timing of incoming inputs. Neuroscience dogma has relied on chemical synapse as the primary signaling mechanism in the brain; however, a new synapse has grown to prominence in the past couple decades[7]. It is the electrical synapse.

An electrical synapse, also known as a gap junction, is a direct electrical connection between two neurons. Channel proteins of the two neurons directly connect their intracellular space. This produces a direct flow of electrical potential between the two neurons. Neurons on distant sides of the brain linked directly via gap junctions synchronize electromagnetic fields for long-range communication[8]. Furthermore, gap junctions dynamically open and close, allowing for selective synchronization of brain regions. Under this light, each brain region does not only perform a specialized functional role, but also participates in a delocalized brain network. Some have theorized that the patterns of traveling coherence correspond to the mind moving around the brain.[9]

RHYTHMIC COGNITION: THINKING IN CIRCLES

Since neural oscillation is becoming fundamental to neuroscience, what then is the cognitive analog? In order to tie subjective experience to the body, also known as the mind-body problem or hard problem of consciousness, it must be acknowledged that cognition is dramatically rhythmic[10, 11]. As you read this, is your leg or finger tapping away a beat? When deep in thought it is not uncommon to facilitate the process by tapping a rhythm with the fingers. When unconsciously tapping away at a desk, one will realize that this is a manifestation of rhythmic neural activity. Thought patterns take on rhythmic periods. As one ponder what to do with the day, there is a cyclical nature to this musing, and the narrator inside the head speaks with a particular time signature.

While solving a difficult problem, the idea is played out multiple times in the head. Each time the problem is replayed, there is a new opportunity to connect the thought to new solutions.

Then there is music. Why do humans love music so much? This is a nontrivial question. Music taps into the nature of humanity because of its rhythmic nature. Some people work at high speed and enjoy music that is equally fast. When people go for a run, they tend to have a certain playlist of music that sets their pace. When performing an action accompanied by music, the optimal beat is the one that best synchronizes with the mood of the listener. The increasing popularity of electronic trance music is due to its ability to entrain slow brain oscillations. Large gatherings, such as the Electric Daisy Carnival, witness tens of thousands of people dancing in synchrony. These festivals resemble the ancient traditions of tribal drum circles, accompanied by ecstatic dancing, for religious purposes.

An astonishing repercussion of neural oscillations is that musical memory is extremely resilient. In fact, musical memory survives Alzheimer's disease and breaks through deep levels of dementia[12]. Dan Cohen went to nursing homes where elderly patients were unresponsive, despondent, and had little ability to recall their childhood[13]. He administered headphones and played music from their era. Suddenly, memories came flooding back. Moods shifted toward joy. The elderly became responsive and communicative once again.

Headaches also profoundly demonstrate the rhythmic nature of thought[14]. When one has a headache, one can feel a pulsating sensation in the brain region affected. It does not take much to end up with an overly synchronized brain region. Isolated cases of seizures are quite common—about 1 in 10 humans—as normal cognition is on a spectrum from recurrent, intense thinking to a headache to a migraine to a seizure. When a seizure occurs in healthy adults, the cause is usually stress related. As an externally generated feeling of panic rises, fear replays in the mind repeatedly. The stress feeds recurrent neural connections. After enough rumination, this brain oscillation takes on a life of its own. The electrical nature of this thought rages in the brain. Neurons synchronize pathologically, and the growing oscillation pillages the ongoing activity of nearby brain regions until it consumes the entire brain. Before a tonic-clonic seizure hits, it has built up for quite some time, and the conscious mind feels its progression. Epileptic patients learn to recognize when seizure activity starts to spread. When the seizure reaches its climax, the whole brain is consumed in a single oscillatory rhythm. In the tonic phase, the whole brain activates and all the muscles in the body lock up. Then, in the clonic phase, the whole brain relaxes and the body goes limp. Then tonic, then clonic, then tonic, then clonic, and repeat until the brain winds down through exhaustion. When someone undergoes a seizure, the rhythmic activity of the brain is clearly visible.

FREQUENCY BAND OF SUBJECTIVE EXPERIENCE

Where in the frequency domain is human subjective experience? It occurs at the scale of the whole brain, in a triple resonance band that is intuitively experienced. This is the Cognitive Triad (figure 1).

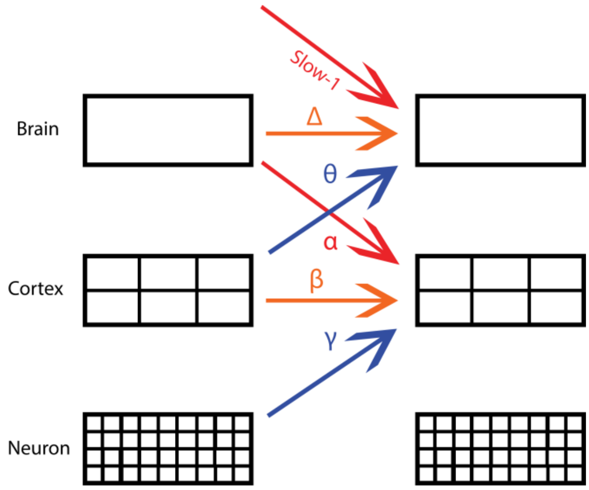

Figure 1. Frequency specific information transfer. Coupling occurs strongest between frequency bands of the same color. Human subjective experience is at the level of the whole brain

The fastest of these bands, theta (θ, 4-7 Hz), corresponds to perceptual awareness of incoming environmental stimuli[15]. Theta binds the details of sensory experience, emerging from dedicated modules of the brain, into gestalt perceptions. In the Cognitive Triad, updates in perception occur about five times per second. Theta frequency has neural correlates in the hippocampus and the neurotransmitter acetylcholine[15,16].

The middle frequency band, delta (Δ, 0.5-2 Hz), drives actions, motivations, and decision-making. When performing a task, the brain orchestrates this behavior in delta frequency[17]. This frequency is linked to dopamine and activity in the prefrontal cortex. About twice per second, the human mind consciously experiences a choice to do something.

The slower frequency band, slow1 (0.1-0.5 Hz), is the rate of epiphany, insight, and perspective-shifts. During meditation, one tries to open the mind and achieve greater attentional control through mastery of mind-wandering. Meditation is naturally linked to this frequency through breathing. If frustrated while working on a problem, one solution is to take a deep breath and access the naturally occurring slow1 frequency. Slow1 oscillation is linked to default mode network activity and loops between the thalamus and cortex[18, 19].

FASTER BRAIN: HARMONICS IN GAMMA/BETA/ALPHA

Directly beneath the level of human subjective experience—in theta, delta, and slow1—is the level of specific regions, or modules, of the brain. There is a correspondence between the Cognitive Triad of the entire brain and that of brain modules at gamma (γ, 30-60 Hz), beta (β, 15-30 Hz), and alpha (α, 8-14 Hz) such that theta-gamma, delta-beta, and slow1-alpha are observed to be coupled and serve a similar cognitive role. The two frequencies can be coupled via harmonics, where the fast frequency is nested inside the slow frequency, or in phase amplitude coupling, where the phase of the slower frequency determines the amplitude of the faster. As an example, the theta-gamma code is coordinated such that the phase of the theta frequency is correlated with gamma amplitude[20]. At the peak of theta, there will be a burst of gamma activity. Then, at the trough of the theta frequency, there will be subdued activity in the gamma band.

Theta-gamma coupling encodes specific sensory information, in gamma band, into an integrated gestalt, in theta band. For example, a mouse is walking along a maze. Each position in the maze has neurons that activate to say that the mouse is in this position. As the mouse moves through space, a sequence of these "place cells" activate. The theta frequency plays the story of the mouse's location as it moves from position A to B to C to D to E[21, 22]. As the mouse moves into location B, the theta cycle plays the sequence of firing A-B-C in gamma frequency. Once the mouse enters location C, the theta cycle plays B-C-D in gamma. Once the mouse reaches location D, the theta cycle plays C-D-E in gamma. The theta-gamma code binds positions in space at gamma frequency into a gestalt trajectory of movement in theta.

When one wishes to remember a trip to a restaurant, there will be brain regions that correspond to particular colors, shapes, faces, locations, etc. These simple perceptions will all be activated in gamma frequency and bound together in theta frequency. Each theta cycle represents an entire object, where the gamma frequency has all the details and qualities of that object[23]. When telling a story, each event in the story is encoded in gamma frequency and bound together in theta frequency. In summary, brain regions will synchronize their gamma activity to represent details, and the theta cycle binds those patterns into a gestalt.

In human perceptual experience, about 5 new *things* reach awareness per second. Each of these things has plenty of details and clearly the background setting of is highly detailed. However, the number of gestalt perceptions striking conscious awareness is quite limited. For a demonstration of the sparsity of perceptual awareness, dramatic changes in perception go completely unnoticed, called change blindness[24].

The beta band corresponds most predominantly to inhibition and the GABA neurotransmitter[25]. Beta acts as a regulator of gamma[26]. When beta activates, it silences gamma synchrony. Delta frequency is the hallmark of evidence-accumulation in decision-making, which works together with beta frequency for response preparation[27]. As you seek a goal in delta, the necessary inhibition is coordinated in beta to suppress distracting sensory data.

Alpha is a correlate of attention, inhibiting distraction, and mind-wandering in thalamocortical loops just like slow1[28, 29]. When you close your eyes, alpha activity consumes the brain. The default mode network (DMN) is a system of brain regions that activate when the mind is at rest, or not performing a task. DMN activity is linked to ongoing alpha activity and switching between DMN and other networks at the rate of slow1. The frontal-parietal (FP) network is primarily activated by a cognitive task and is associated with delta-beta activity. The slow1 oscillation, at about 0.1 Hz, sets the timing of switching between task-negative DMN and task-positive FP network[18]. This oscillation is most representative of the whole brain's mode of activity, which includes dramatic shifts in subjective experience, from mind-wandering to active thinking.

TESTING THE THEORY: BRAIN STIMULATION & NEUROIMAGING

The best avenue to study the Fractal Cognitive Triad is brain imaging and neurostimulation. The methodologies that record electromagnetic oscillations in the human brain are electroencephalogram (EEG), magnetoencephalogram (MEG), and electrocorticography (ECoG). Functional magnetic resonance imaging (fMRI) also studies neural oscillations at slower frequencies, near 0.1 Hz, but in terms of demands for freshly oxygenated blood. These technologies are augmented by brain stimulations that entrain oscillations or disrupt/reset/boost ongoing oscillations. Transcranial alternating current stimulation (tACS) introduces a sinusoidal current into the brain that drives neurons at its frequency. Transcranial magnetic stimulation (TMS) applies a high intensity magnetic field to the brain for a brief period of time, less than a millisecond. Since the stimulation is quite brief, a series of TMS pulses can be delivered at a specific frequency that boosts natural oscillations[30]. Pairing tACS or TMS with EEG or fMRI can alter oscillations during a cognitive task and provide causal manipulation of frequencies of interest. Cognitive neuroscientists are currently testing similar theories to Fractal Cognitive Triad, but this theory provides a needed overarching model of oscillatory cognition. The distinction between theta-gamma for bottom-up processing and delta-beta for top-down processing has received the most attention thus far[31, 32, 33, 34, 35].

WHAT GOES UP MUST COME DOWN: EMERGENCE & SUBMERGENCE

A fundamental assumption of the Fractal Cognitive Triad is that causality occurs at many scales of biology. It is often assumed in science that the microscopic level of physics is the only level of causality (figure 2A) [36]. Cells, proteins, molecules, and the mind are all elaborate illusions[37]. Everything is dependent on the fundamentally small scale. This undervalues the study of slow frequencies and explains the early resistance to neural network theories.

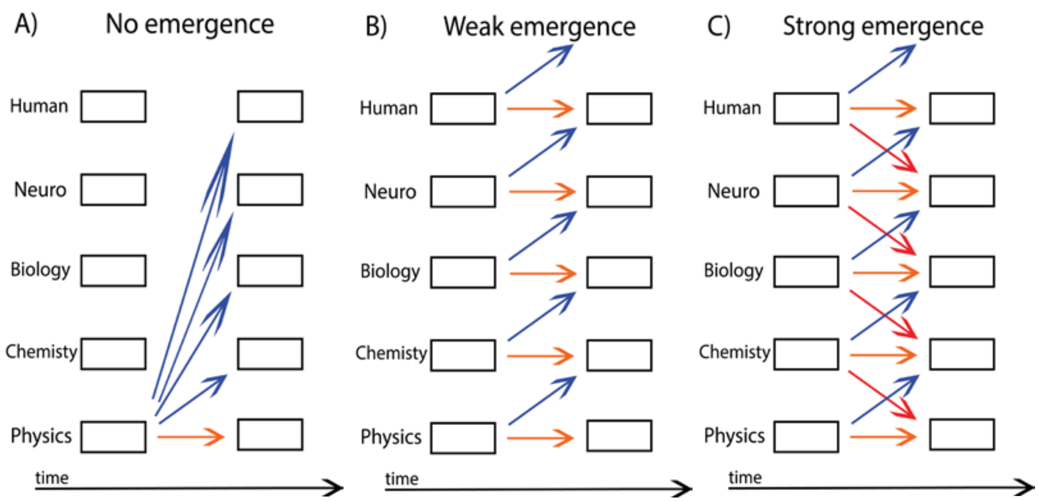

Figure 2. A) No emergence says causality is at the fundamental level of physics. B) Weak emergence allows for new structures with supervenient macrostates. C) Strong emergence adds downward causation from macro to micro.

Mark Bedau supports the notion that weak emergent structures, such as a tornado from air particles, have macrostates that are supervenient to the underlying microstate[38]. An analogy helpful in understanding the role of weak emergence comes from levels of abstraction in computer science. When writing a program in Java, a computing language, you do not worry about the 0s and 1s underlying the computer architecture. Each line of code is compiled into operations at the level of circuits and binary at the fundamental level, but there are levels of abstraction along the way that mask out the fine details. This is a perfect model of weak emergence. In this analogy the mind is like the Facebook application, creating friendships and "liking" content, while the brain is the Java code that executes these programs. The biological infrastructure of the brain is the machine code faithfully computing away the 0s and 1s which make all of this possible. The Java code is supervenient to the details of the binary, but does not violate the fundamental laws of the digital computer. The human mind is only an abstraction and no different from the binary rules that make up the fundamental level.

The shortcomings of weak emergence are demonstrable when the human mind is taken into account. Weak emergence would never allow human consciousness to influence the brain directly, called downward causation. Imagine having a conversation between friends without downward causation: When friend A tells friend B about his escapades last night, his brain generates the necessary words and transmits them through the vocal cords to friend B's brain. Her experience of his words emerges into her mind and she appreciates the meaning of the story. She cannot send her reaction down into her brain, because that would be downward causation. Instead, the brain generates its own response, which is sent over to friend A's brain. The conversation is an epiphenomenal illusion. The slow rate of language is supervenient to the fast neural firing, such that without downward causations the friends are helpless spectators to the workings of their brains. In weak emergence, consciousness is more like watching a movie, than playing a video game. Your choices are the result of a long complex causal chain of brain states[39].

Tony Bell at University of California, Berkeley has been developing a theory of submergence.[40,41] Bell argues that emergence alone is suboptimal according to Occam's Razor, because information only flows in one direction: from the bottom up. Submergence is a new concept that says macroscopic systems can cause and create the microscopic, from the top down. Going back to the conversation between friends, their conscious experience still emerges from neural interactions. As words enter the cochlea, they are converted into gestalt perceptions for the slow oscillations of the entire brain. When friend A experiences this gestalt perception, he formulates a response that is sent down into his neural architecture. This information is then transmitted through his vocal cords over to friend B's cochlea. In this framework, two minds can genuinely communicate. When trying to explain a fast conversation between two intellectuals in terms of neurotransmitter release and subatomic spins, the model loses all meaning of the conversation and is unnecessarily complicated.

Walter Freeman applies strong emergence to neurophysiology, suggesting that macroscopic brain oscillations emerge to integrate perceptual experience, form a behavioral response, and submerge back into cortical modules for execution[42]. The downward causation from the entire brain to the modules represents the choice of the organism. In this model, consciousness exists as an emergent field in the brain.

Timothy O'Connor defines strong emergence as a property held by the whole that is not explainable by a mere sum of the parts[43]. Quantum mechanics offers the best mechanism by which the whole is truly greater than the sum of the parts. A wave function that governs many possible physical states is not describable in terms of the physical states alone. Superfluids and superconductors offer a particular example, where, under the proper conditions, many disparate physical systems are enveloped into a single wave function that has downward causality to its constituent parts.

HOMUNCULUS SOLUTION

Evidence is accumulating that biology is composed of quantum computers, from cells to proteins[44, 45, 46, 47]. Quantum coherence (QC) is the primary requirement for quantum computation in which a system is sufficiently isolated from the environment, and the subtle properties of quantum theory become dominant. A single wave function emerges to govern all of the parts and serves as a candidate for mental experience, for a variety of reasons: 1) macroscopic unity of self, 2) freewill to collapse the wave function, and 3) oscillation inherent in collapse rate. Finally, quantum computers are nested inside of each other across scales of magnitude, as shown in figure 3, giving way to strong emergence.

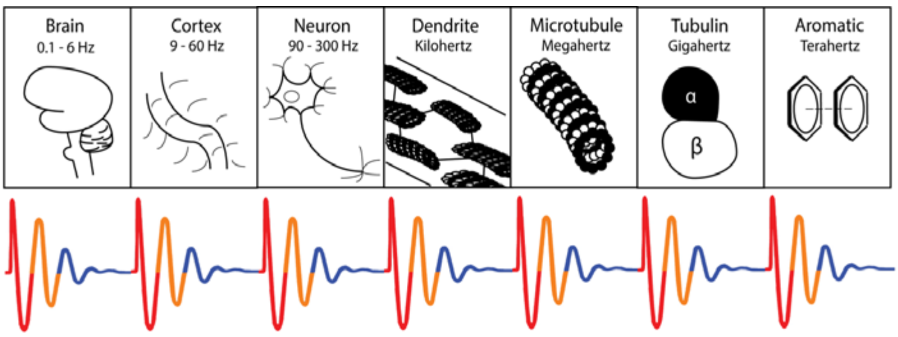

Figure 3. Distinct levels of resonance that scale orders of magnitude from the whole brain down to pi-stacks of aromatic rings

The fractal nature of the human body has long been appreciated. When you measure raw electrical activity from the brain, it forms a 1/f power spectrum, called pink noise[48, 49]. Pink noise is found when measuring all biological systems, from proteins to the brain to the entire body to nature[50]. The Feigenbaum ratio is fundamental to fractal geometry in describing the rate at which a pattern will reoccur in a fractal. When watching a movie that zooms in on a fractal, after a certain amount of time, the starting pattern remerges. In fractal biology, the Feigenbaum ratio is a fundamental aspect of information processing[51]. There is a locus of cognitive experience at fixed intervals when zooming in. These are proposed to be the scales at which biology has established QC. If subjective experience originates from a particular quantum computational level—say, the level of the entire brain—then zooming into regions of the cortex reveals QC an order of magnitude smaller and faster in frequency, as predicted by the Feigenbaum ratio. At each level, quantum minds are undergoing quantum computation to experience their own cognition.

The Homunculus Problem was proposed by Daniel Dennett as a way to question the validity of qualitative experience[39]. Is there really a little person inside of the body pulling the strings? That little person would require a little person inside of his head, ad infinitum. The Fractal Cognitive Triad embraces and rephrases this as the *Homunculus Solution*: inside every biological quantum computer are quantum computers, a scale of magnitude smaller. These are the voice in the head of the quantum computer which communicate via a new form of information processing called "frequency fractal computation."

FRACTAL COMPUTER: ALL THE BELLS AND WHISTLES

Submergence & emergence might be implemented in biology using frequency fractal computing, pioneered by Anirban Bandyopadhyay[52]. The core of this computer is actually not a core at all, but layers of material that oscillate across orders of magnitude. There is fine material, which oscillates in fast frequencies, and gross material, with slow resonate frequencies. Bandyopadhyay synchronizes the resonant frequencies such that, for a given material, the slowest resonant frequency synchronizes with the fastest resonant frequency of the material an order of magnitude larger: emergence. The fastest resonant frequency synchronizes with the slowest of the material an order of magnitude finer: submergence. Finally, there is a resonant frequency in the middle, which is unique to that level. Each level communicates up and down one level in scales of magnitude. Viewed collectively, interface with any level will resonate throughout the entire structure; therefore, the output resonance at every level is dependent on the whole. According to Bandyopadhyay, this fractal arrangement of resonance gives rises to novel computation, which does not need to be explicitly programmed.

Bandyopadhyay was inspired to design the fractal computer by studying the inside of neurons. He isolated individual microtubules and measured their resonance properties[53]. He found three distinct resonance bands in the megahertz range (figure 3). Microtubules are composed of tubulin proteins. Similarly, tubulin proteins resonate in three distinct frequency bands, but in the gigahertz range. Most intriguing, he found that interfacing with a single tubulin protein in one of these frequencies altered the resonant properties of the whole microtubule. When he measured large bundles, or networks, of microtubules, he found, yet again, a triple resonance band in the kilohertz range. Although not directly tested, these macroscopic resonance properties may orchestrate with resonant frequencies at the microtubule level. This model gives rise to a picture of biology as a fractal computer. Activity at any level will affect the entire system.

Henry Stapp's theory of Quantum Zeno Effect (QZE) for coordinating bodily function is worth noting here[54]. In his theory, the mind chooses a template of action from its Hilbert space of possible functions. Upon collapse to this choice, this template is propagated down into biology and, over time, trains the body to perform complicated actions from simple templates. This fits nicely in the Fractal Cognitive Triad, where subjective choices are treated as templates that submerge (downward causation) into the biological fractal computer to orchestrate behavior.

TRIAD OF COMPUTERS

In summary, my overarching metaphysical model is that the body is a digital computer, the mind is a quantum computer, and the spirit is a fractal computer[55] (figure 4). The three-world model is inspired and adapted from Roger Penrose[56]. At every level of the fractal computer, there are quantum computer minds entangled to each other, most directly to quantum computers one level higher and one level lower in the fractal. The quantum computers at lower levels are nested within the higher levels. In this way, they genuinely emerge into a larger quantum computer, and the higher levels submerge into their constituent quantum computers.

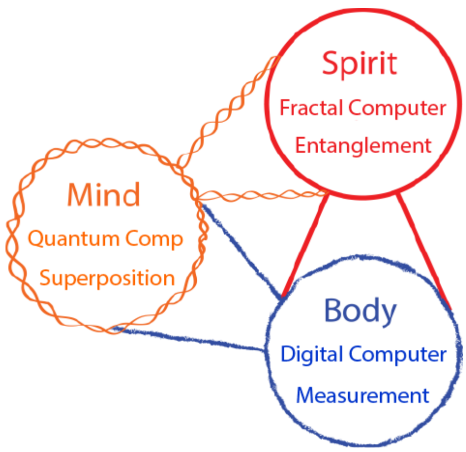

Figure 4. The implementation of the Fractal Cognitive Triad in biology requires a digital interface for quantum computers nested within each other to form a fractal computer that spans many orders of magnitude

VOICES IN YOUR HEAD

In addition to the biological model, the Fractal Cognitive Triad is supported by introspective and meditative practice. The principle of submergence and emergence means there are voices inside your head that are communicating and vying for your attention. When you are conflicted over a choice in your life, this theory suggests there are tiny conscious beings inside your brain that are operating at a faster frequency and discussing or arguing among them about your appropriate action.

The voices in your head are not at the level of your subjective experience, but they emerge into your consciousness and submerge from your consciousness. There is a resonance between those voices and yourself. In other words, you are a fractal computer that extends down through these levels, but your subjective awareness is at the level of the whole brain, your quantum computer. Even deeper in the fractal computer, the neurons in your brain demonstrate their own conscious awareness that submerges from cortical structure and emerges from microtubule formations.

David Eagleman's book *Incognito* explores how the mind can be unaware of the unconscious functioning of the brain[57]. Humans often claim ownership of thoughts and actions, but all too often react without conscious thought or stumble upon a bright idea with no pretense for the discovery. Eagleman equates human thought to newspaper headlines and the brain to the happenings of the entire human race.

The act of meditation can be used to access the levels beneath the level of consciousness. Experienced meditators have found that they are able to dive into the perception of a particular voice in their head[58]. Once in that perception, they can start making alterations that are more in line with their ideal behavior. These voices are usually beneath awareness, but their influences are dramatically felt. For true transformation of self, it may be necessary to submerge into the brain and reprogram the neural underpinnings of conscious experience.

Richard Schwartz is a family therapist who realized, in the course of treating his patients, that it was not sufficient to consider each patient to have a single personality[59]. He discovered that his patients had Internal Family Systems, in which there were many personality types acting dysfunctional together. He found a system to address these parts of the patient and bring the whole system into harmony. In the Fractal Cognitive Triad, humans have a single self, but are made of many parts that act, primarily, autonomously.

Rhawn Joseph suggests a model where streams of consciousness merge and diverge[60]. In split-brain patients the connecting fiber between the two brain hemispheres is cut. It seems that two different conscious experiences are taking place simultaneously. Which side of the brain is the subjective experience of the whole person? It is not clear. The left hemisphere can speak since it controls language, but the right hemisphere displays its opinion in bodily control. In certain cases, the different hemispheres are exhibiting emotional experiences vastly different from each other. Perhaps, in split-brain patients, the level of the whole brain at theta, delta, and slow1 is cut in half into two different subjective experiences.

ZOOMING OUT INTO COLLECTIVE CONSCIOUSNESS

What is the level higher than human subjective experience in the fractal computer? This is the level of social interaction. When two people begin a conversation, they create an oscillatory system that exists at a slower timescale than either person, but emerges from the interaction. The frequencies of collective consciousness are the periods of awkward silence; the length of time that is appropriate for one person to speak at length; the subtle check-in with each person to the group. In this sense, social skills may be equivalent with the ability to resonate with oscillations one order of magnitude slower than subjective experience.

Even higher levels can be reached when alone in a meditative state or with group meditative exercises. Sperry Andrews has developed a technique of collective conscious experience in which the group openly shares ongoing conscious experience and discusses the meaning of self-awareness, while making eye contact[61]. At the extreme end of this zooming out practice, people report expansiveness and oneness with the universe. In the Fractal Cognitive Triad, one can allow even higher levels to submerge into subjective experience.

What are the levels of QC larger than the self? Given that scientists are still trying to establish QC at biological levels, such as proteins and microtubules, it is a bit premature to discuss potential sources of QC larger than the body. Could the entire Earth be conscious? This seems farfetched in modern science, but many mystical traditions believe Earth to be a conscious being. If true, then Earth's awareness would exist many levels above the human level in the fractal computer. Perhaps each human being is a like a neuron in the brain of the Earth. We are the voices in her head.

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