Perspective

The *Qualk* Hypothesis of Consciousness (Part I)

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Abstract

Despite being a remarkably old and fundamental human conundrum and having sensible clinical situations in need of it, there is not yet a theory that truly explains consciousness itself - neither on the empirical level nor on the conceptual level. Consciousness theory has not achieved the deserved scientific order nor freedom from contradictions. Here I propose a new organized structure for the problem as well as an outline for a solution with a biological foundation. I propose answers to the questions of what consciousness is and what consciousness is for. I go from phenomenology to biochemistry and back, while reviewing several dense components related to the topic along the way. I argue that, at the fundamental level, consciousness is a rich dynamic symphony of individual distinct detections (*qualks*), without the need for any physical unification.

Keywords: Consciousness, hypothesis, qualk, biological foundation, phenomenology, distinct detection, biochemistry.

Introduction

Glossary

Presented here is a self-coherent glossary with short definitions of the necessary concepts used throughout this article. Failure to make such distinctions, despite persuasive intimate relations or confounding different concepts, often leads to mistakes in interpretations of results, formulations of models, proposals of experiments, and general coherence across the field.

1. Consciousness: subjectively explicit experience; what it *is* to *be* the conscious subject [171]; the collective of distinct felt detections (qualks) present at a particular moment.
2. Background conditions: "factors that enable consciousness without contributing directly to its content" [170].
3. Recursion [111]/re-entry [112]/recurrence [113]: It consists in having later areas modulating earlier areas. It seems to be highly involved in the modulation of conscious detections.
4. Wakefulness/arousal/alertness/vigilance: The active state of the support systems that allow the normal operation of consciousness and associated processing neural

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networks.

5. Responsiveness: The ability to perform meaningful behavior in response to what was specifically asked.

6. Reportability: The ability to further process and communicate information about conscious states to the exterior.

7. Integration/Unification: Combining parts into single new whole entities; transformations to the parts and/or interconnections between the parts must occur. (Examples: summation of post-synaptic potentials that reached a threshold potential).

8. Ensembling/Composition: Arranging parts within a common role and performing simultaneously; transformations to the parts and/or interconnections between the parts don't have to occur. (Example: pixels in a screen)

9. Qualia: The distinguishable phenomenal properties of consciousness; the perceived qualities of subjective experience; how consciousness seems *to* the conscious individual. (Ex: the painfulness of pain). A quale can actually involve several qualks, and different qualia might actually involve different arrangements of the same set of qualks.

10. Qualks: The fundamental elements of consciousness; QPUs' felt detections as felt by each respective QPU itself, in an active phenomenon. (Ex: the massive symphony of auditory and feeling qualks experienced while listening to a piano concerto).

11. Phenomenal richness: The amount of different qualks in a collective conscious experience; the higher the differences, the higher the richness. (Ex: An individual who cannot see color or who cannot perceive sound has less phenomenal richness available).

12. Neural Correlate of Consciousness (NCC): "the minimal set of neural events that give rise to a specific aspect of a conscious percept" [172].

13. Qualk Processing Unit (QPU): Biological neural units capable of experiencing a distinct qualk when they are activated. (Ex: the unit activated when we experience its red-detection in our collective visual field).

14. Non-QPU: Biological neural units not capable of experiencing a distinct qualk when they are activated. (Ex: a Purkinje cell).

15. Exogenous activation: Informational input that contributed to the activation of a QPU and originally came from *outside* the brain. (Ex: The detection of photons in the retina).

16. Endogenous activation: Informational input that contributed to the activation of a QPU and originally came from *within* the brain. (Ex: Tinnitus auditory hallucinations).

17. Self-consciousness: Qualks about the self. (Ex: When immersed in a movie, we can temporarily loose self-consciousness).

18. Conscious self-cognition/introspection: Conscious cognitive operations about ourselves; thinking about ourselves using conceptual knowledge and mental contents related to our self.

19. Self-recognition: Capacity to recognize us as us and to recognize our belongings and actions as ours, based on internal models with autobiographical memory and self-cognition.

20. Non-cognitive processing: Neural computations not representing something beyond the physical neural computations themselves. (Ex: patellar reflex).

21. Cognition: Neural computations representing something beyond the physical neural computations themselves, often manipulating mental content. (Ex: Interpreting and activating the meaning of written words).

22. Unconscious cognition: All cognition that is not using conscious detections; the term is preferable to the misleading "unconscious" or "subconscious". (Ex: Walking the right path home while consciously thinking about something else).

23. Conscious cognition/Thinking: Prolonged and coordinated cognitive operations using the felt vocabulary of qualks present in the mind. (Ex: Solving a riddle).

24. Metacognition: Cognition about another cognition.

25. Awareness: Meaningful perception of something in the surroundings; knowing about specific incoming information.

26. Intelligence: The ability to apply knowledge and cognitive processing to reach new solutions, which can become new knowledge and/or new cognitive processing.

27. Theory of mind: The cognitive ability to model and simulate in ourselves what might be happening in the minds and cognition of others.

28. Imagination: The ability to reach new meaningful compositions in the mind and the respective cognitive framework, beyond common perception.

29. Hallucination: Illusory conscious perception, often unsolicited and uncontrollable, representing something which, unlike in normal sensory perception, is not existing

outside our mind.

30. Representation: Something portraying properties to describe something else; a signifier standing for a signified; it is meaningful within the appropriate interpretative framework.

31. Implicit representation: An implementation of a functional description; usually depending on relations between elements; used in cognitive meaning. (Ex: firing of grid cells in the entorhinal cortex).

32. Explicit representation: A representation with concrete components experienced by the subject; usually dependent on the elements themselves. (Ex: A red qualk).

33. Bottom-up attention: Salience-driven, local and involuntary neural bias mechanisms that can manage processing resources and usually the activation of conscious content through positive and negative modulations, with the overall effect of gain control [119].

34. Top-down attention: Cognitive, long-range and willed neural bias mechanisms that can manage processing resources and usually the activation of conscious content through positive and negative modulations, with the overall effect of gain control [173][174][175].

35. Learning: Acquisition of new meaningful information and knowledge using previous states.

36. Memory: Acquired embodied information that can be held in time and used in cognition, and usually to activate conscious content. There are different instantiations of it, as long-term, short-term, working, and iconic memory, different mechanisms and encodings, and involvement in different modalities. Memories are mainly based on synaptic modulation and plasticity, and to a certain extent on functional changes in other structures of neurons themselves. Memories such as those of events can be activated and cause the performance of recalled conscious detections through processes such as time-locked multiregional retroactivations [176]. The word "memory" is also commonly used to refer to memory *capacity*.

37. Knowledge: Structured, meaningful and useful cognitive or procedural information, acquired *using* internal modelling and *in* internal models, with parts that could be used in conscious cognition. It implies order, regularities and relations. It is stably instantiated through memory.

38. Self-knowledge/autobiographical knowledge/autobiographical self: Knowledge containing multi-level descriptions and associations between descriptions related to the

individual, representing a minimally integrated concept; what we know about ourselves and about how we fit within the rest of things.

39. Understanding: The cognitive ability to in our terms make sense of information that we are processing, in the form of active knowledge; different contents become well and orderly associated in a way that instead of having to be externally and individually activated, we have achieved the right cognitive framework so that we can go from one content to the other with full control, autonomy and efficacy. One can have consciousness without understanding and understanding without consciousness.

40. Desires/urges/intentions: Convergent cognitive forces that use conscious elements to project affordances and which drive behavior.

41. Moods: Overall integrated drives and emotional states.

42. Drives: "An action programme that is aimed at satisfying a basic, instinctual physiological need. Examples include hunger, thirst, libido, exploration and play, care of progeny and attachment to mates" [177].

43. Emotions: Objective, efficient, coherent, well-scripted, and reproducible orchestrations of neural and somatic actions to bias cognition, mood, mental states and behavior towards what matters to the organism as selected by natural evolution. Usually they happen as a reaction to somatic or cognitive events, to some change in our internal states or to some projection of a potential change, positive or negative. Even the common parasympathetic freezing reaction involves complex orchestrations in the amygdalae that then project to the brainstem [178]. Emotions reveal an implicit care for the state of the body. They can range from low-level to very high-level phenomena, such as joy, shame and guilt. Emotions are not cognition. For example, individuals with lesions in the amygdalae can fail to show normal physiological responses and fear conditioning, when repeatedly presented with fearful stimuli, while nevertheless being perfectly capable of describing knowledge about the facts [179][180] and sometimes even showing "curiosity" [181]. In addition, emotions should not be confused with emotional *feelings*.

44. Feelings: Dynamic ensembles of self-quality-qualks within appropriate cognitive and semantic frameworks and usually causally related to visceral somatic states [177]. In general, continuously present throughout conscious states, even if very subtle and ineffable. Without feelings, there would be no pain and no pleasure.

45. Perception: The neurobiological interpretation of incoming sensory information, from biochemical detections at a variety of sensory receptors to all modular and interacting processing upstream. It is always an *active* interpretation. Perception does not have to cause conscious detections along the way and consciousness does not have to be

caused by perception. Perception does not have to imply behavioral responses.

46. Amnesia: From *a-* 'not' + *mnesi-* 'remembering'; no memory of previous experience.
47. Analgesia: From *an-* 'no' + *algein* 'pain feeling'.
48. Sedation: Purposeful reduction in the somatic excitation capacity of the nervous system. Sedatives should not be confused with analgesics or anesthetics.
49. General anesthesia: Controlled drug-induced coma. Not to be mistaken with deep sleep.
50. Deep sleep: Slow wave sleep stage. The individual can respond to some stimuli and at least be awaken.
51. Coma: A condition of continuous unresponsiveness and absence of wakefulness in which the individual keeps his eyes closed and cannot be awakened. It is usually correlated with a significant decrease in brain metabolism. Usually, within a few weeks it transitions into UVS, MCS, normal consciousness, or brain death.
52. Unresponsive Wakefulness Syndrome (UWS): A condition in which, unlike coma, the individual has intermediate periods of wakefulness, opens his eyes, and might show reflexive responses to strong stimuli, but does not show meaningful responsiveness, voluntary behavior, communication or cognition. It is usually correlated with a significant decrease in brain metabolism [182].
53. Minimally Conscious State (MCS): A condition in which the individual has intermediate periods of wakefulness [186] and episodes, though minimal and inconsistent, of meaningful responsiveness and voluntary behavior through which awareness of the self and of the surroundings is demonstrated [185]. Nonetheless, generally the individual remains unable to communicate meaningfully. There is a very high risk of misdiagnosing this condition as UWS [184]. There are several described cases of MCS patients who regained the ability to speak after many years [183].
54. Locked-In Syndrome (LIS): A condition in which the individual has essentially normal consciousness, sleep-wake cycles and cognition but is unable to control his body, although usually able to communicate through small eyelid movements [187][188]. There is a very high risk of misdiagnosing this condition as UWS.

15 years ago, Francis Crick and Christof Koch published an article [1] where they arranged an up-to-date framework for the solid scientific study of consciousness. Nonetheless, they begun by asserting that: "No one has produced any plausible explanation as to how the experience of the

redness of red could arise from the actions of the brain. It appears fruitless to approach this problem head-on."

Even more than the correlates of consciousness, consciousness itself is still unexplained. This fact is an absence in the potential of science, an absence at the clinic, and an absence in our fundamental self-understanding as conscious beings.

Due to a fertile amount of rigorous scientific research already achieved, consciousness is today a serious and rich scientific endeavor.

In this article, not only will its surroundings be organized but the problem of consciousness itself will also be tackled. An organized framework will be proposed to answer the questions of what consciousness is, how the brain gives rise to consciousness, and what consciousness is for.

Cleaning Up the Workspace

Consciousness is a master example of language as the source of many conceptual mistakes and unnecessary confusion, sometimes as much as it enables us to talk about this topic in the first place. We can be lead not only into useless contributions but also into negative misleading ones. The word 'consciousness' is commonly used to refer to several different and ambiguous things. This is an unnecessary mistake, with heavy consequences to clarity and progress. Here, consciousness is defined with what should be its only meaning: subjectively explicit experience – not something *else* (see Box 1). Noteworthy, the central hypothesis presented here is not about conscious *cognition*.

1. From Phenomenology Down

There are easily and widely accepted axioms concerning intersubjective and objective characteristics of consciousness. Some of them are the following:

1. We experience *different* things.
2. Those things can have bigger and smaller differences (Figure 1).
3. Each thing has a *phenomenal identity*, with concrete inherent information.
4. Each thing has a *structured distinctiveness*, not only when present with others but in and of itself. There is *phenomenal structure*.
5. They are *conserved* across time.
6. Some things refer more to the *self* (e.g., hunger) and others more to the rest of the *world* (e.g., green).

7. Some tend more to *feel* (e.g., hunger) like something and some tend more to *look* like something (e.g., green).
8. Those things can be activated by exogenous or endogenous stimuli, originally from outside or from inside of the brain, respectively.
9. The activation of those things is *thresholded*.
10. Bottom-up and top-down attentional mechanisms can modulate the experience of those things.
11. The *dynamics* of those things are very fast in human terms.
12. Lesions in some *specific* areas of the brain cause the loss of the potential to experience *specific* things. Well-studied clinical examples are achromatopsia and akinetopsia.
13. Stimulation of some specific areas of the brain causes the experience of specific things [2].
14. The experience of some specific things correlates with the activation of some specific areas of the brain.
15. The experience of those things is dependent upon *metabolic activity* of neurons within the brain.
16. The experience of those things is not necessarily dependent upon the activity of most neurons of the brain.
17. The experience of those things is independent of the ability to *report* them to the exterior.
18. The experience of those things only seems what it seems to the respective conscious subject himself.
19. We experience reality through those things.
20. We can experience a *large number* of those things simultaneously.

It is useful to attend to all these characteristics because despite concerning subjectivity, they nonetheless point to necessary direct *instantiations* in objective reality.

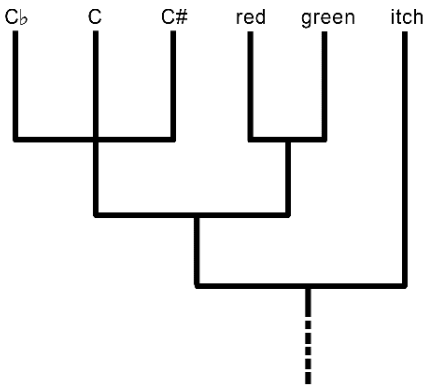

Figure 1. Qualk tree illustration. The subjective phenomenology of qualks suggests a tree-like organization. The examples are mere illustrations of what different types of qualks could be or compositions of qualks.

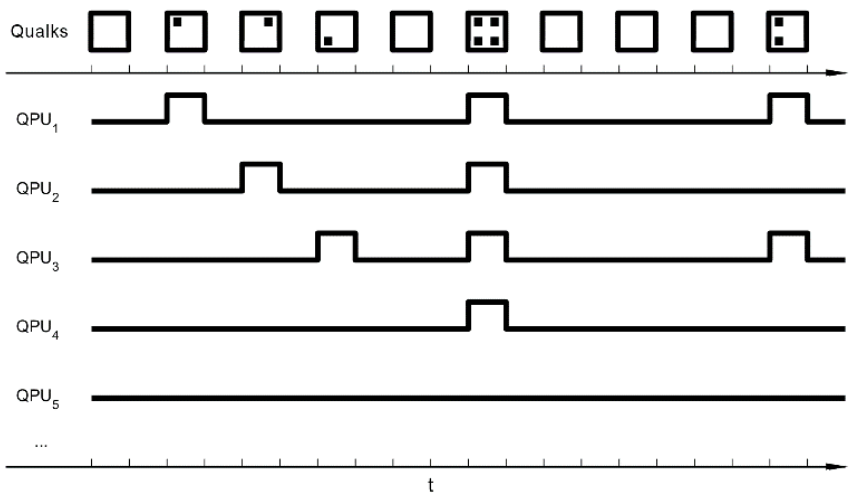

Figure 2. QPUs time course illustration

1.1 The *Qualk* Hypothesis

The qualk hypothesis proposed here states that consciousness is made up of discrete fundamental elements – qualks (qualia's quarks) – and that each of those elements is instantiated in a respective individual biological substrate – a qualk processing unit (QPU).

Each qualk is what it is to *be* an activated QPU. Qualks are not things in themselves, but only what the detection *seems to* the respective subject's QPUs – a *distinct felt detection*. There is the actual objective mechanism going on and there is the subjective experience of *being* it. Qualks work as a *felt vocabulary*. A conscious moment is always an active ensemble of elements from that vocabulary (Figure 2).

The definition of this qualk hypothesis can be concisely described in a brief equation, where consciousness is represented as a disjoint set of qualks, each corresponding to the activation of its QPU:

$$C = \overbrace{\bigcup_{i=1}^{n}(qualk_i)}^{\text{SUBJECTIVE ONTOLOGY}} = \overbrace{\bigcup_{i=1}^{n}(QPU_i \times activation)}^{\text{OBJECTIVE DESCRIPTION AND SUBSTRACT}}$$

According to this hypothesis, consciousness is simply a massive symphony of qualks. Each QPU is like a different key on a piano, able to produce its distinct note when played and collectively

able to produce the symphony of consciousness in time and patterns (Figure 3). The piano player is the overall cognitive processing, which *uses* the piano. According to this hypothesis, consciousness detections are fundamentally passive, *used* within cognitive processes that have the active roles.

Of note, the symphony is not being presented to some fallacious homunculus: one *is* the symphony. Although there are certainly many exogenous and endogenous directions, learned operations and basal chunks of scores in memory, this symphony is being created as it happens.

The exact qualks making up even a very specific conscious percept could be far from obvious.

There is no need to "make" the conscious elements in each conscious state, but simply to activate and use them - once more, just like a vocabulary. There is no consciousness without conscious content and there is no conscious content without consciousness. Consciousness *is* content.

This is exactly what one experiences, only interpreted through this hypothesis: I (collective) have my consciousness (collective). One experiences $qualk_1$ *and* $qualk_2$ because one *is* QPU_1 *and* QPU_2, simultaneously activated in the present moment. In consciousness *itself*, there is simply one conscious detection *and* another conscious detection, and so on. Furthermore, of course, all this is happening within implicit cognitive frameworks and with our knowledge, our cognitive processes and our action in the world, which give the overall sense and ultimate behavioral function to what we are consciously experiencing.

Conscious detections are parallel as a collective *and* serial at each detector.

Other hypotheses impose a theoretical homogeneity, but here we start precisely from the raw *heterogeneity* of the elements of consciousness, evident from phenomenal experience to neurological practice. It is never reduced either. It is the main key throughout this paper. This approach seems much more loyal to what are the products of natural evolution and not of conceptual engineering.

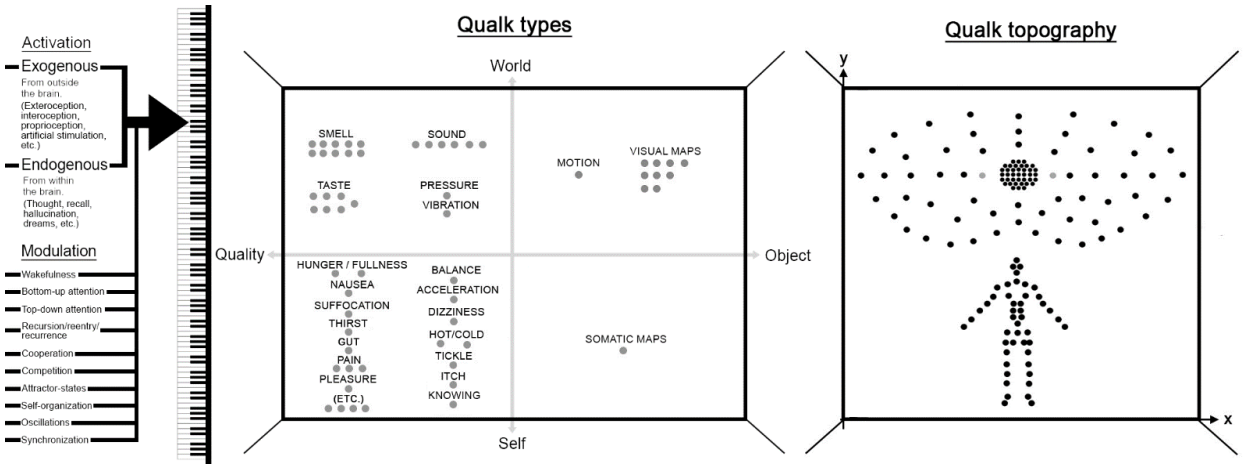

Figure 3. Scheme of the qualk hypothesis, with qualk types and topography. Types of activations of QPUs, types of modulations, illustrative examples of types of qualks organized across two axes, and illustrative topographies made up of qualks. Importantly, these topographies do not consist of actual physical space, but our overall cognitive *representation of space*, within which qualks are used. Moreover, QPUs do not even have to be physically arranged in any kind of regular physical topography - although often that strategy is used due to several practical advantages.

1.2 The Notion of Discreteness

In general, this hypothesis shares its nuclear assertion about the discreteness of consciousness with previous insights from several authors: Hume's "bundle of perceptions" [3], MacLennan's "protophenomena" [4], Eccle and Pribram's "units of mind" [5][6], Julesz and Schumer's "perceptual atoms" [7], Llinás' "proto-qualia" [8], Zeki's "micro-consciousness" [9][10], Escobar's "quantized visual awareness" [11], Edwards and Sevush's "neuron sentience" [12] [13], and Cook and Damasio's "cellular excitability" [14]. Importantly, these insights came from distinct backgrounds and reasons and nonetheless converged on a general central idea. Conscious detections are also discrete in time (Figure 2). There is not somehow a "continuous conscious field" transitioning between completely different contents. Each qualk has a duration in time and in and of itself has independence from all the other qualks. Thus, the several forms of memory and cognition are fundamental for the coherence of our conscious experience in time.

1.3 QPUs

With consciousness reduced to its elementary qualks, the question is not what the neural correlates of our usual massive consciousness are in general but what the neural correlate of each qualk is. The question is framed both in terms of identifying a generic basal mechanism and in terms of identifying differences in variations of them.

Where does the representational information of qualks come from? Where is the information of the redness of red? Where is the information that makes red different from blue and even more different from pain? Not the information that *caused* the activation of red, but *of* red itself. Where *is* that information?

According to this hypothesis, the information inherent to a qualk is not contained in the input signals nor in the output signals but in the temporary QPU itself. The exact same inputs and outputs might have been involved in a temporarily different qualk or no qualk at all. As an analogy, we can consider external inputs that an individual receives and consequent behavioral outputs of the same individual and realize that, despite potentially correlated, the information of consciousness is not contained in either of them, but in the temporary individual – then we simply need to continue to reduce this framework down to the level of each individual QPU.

Here there were also some important related insights previously defended by some authors: Freud's "perceptual neurones" [15], Barlow's "cardinal cells" [16], although he applied the notion in overall perception and denied the counter-intuitive possibility of elements of subjective experience at the level of "isolated nerve cells" [17][18], and Crick's "awareness neurons" [19]. Also, in 1990, Crick and Koch declared the following: "Our basic hypothesis at the neural level is that it is useful to think of consciousness as being correlated with a special type of activity of perhaps a subset of neurons in the cortical system (…) At any moment consciousness corresponds to a particular type of activity in a transient set of neurons that are a subset of a much larger set of potential candidates" [20].

Each QPU works as a detector with certain embodied subjectively representational information. The inputs only *activate* it and the information of the qualk is already in the QPU itself.
Obviously, each QPU only detects what *it* detects. No QPU is making detections for another QPU - otherwise it would have to *be* that QPU. It similarly makes no sense to say that an individual is or is not conscious of the consciousness of another individual.

A qualk is an emergent property of the activation of some biological QPU mechanism. The phenomenological and empirical properties of qualks described before must be instantiated in neural QPUs. Assuming painfulness as one elementary qualk, a QPU does not *detect painfulness*, it simply *detects*, but in a "*painful way*".

The present qualk hypothesis requires the ability to biochemically *detect* and to detect in a *felt* and *distinct* way. There would also have to be millions of different units like that.

According to this hypothesis, the phenomenal properties of conscious detections do not emerge at the level of electrons or at the level of the "whole unified brain" but at the reasonable level of each single neural QPU as a sensible biological entity. Thus, qualks are meaningless at a lower level of description but are meaningful at a higher level of description only in the sense that it *includes* neural QPUs - as one could say that the universe is conscious since it has conscious beings in it. The claim for scale-free fractal phenomenology is not supported by any evidence or any logical necessity, and it is not asked from any other regular emergent properties, which by definition of emergence *emerge* at some level of complexity.

A neurophysiologist might record similar activities in a QPU and in a non-QPU, but the difference would be in the QPU itself. The same would be true between a QPU_1 and a QPU_2. The information of the respective qualk is structural to the QPU itself. Thus, to identify a qualk, one needs not only to know that a QPU is activated but also *which* QPU is activated.

According to this hypothesis, consciousness is ultimately limited because QPUs themselves are limited. There are usually cognitive and structural reasons before that, but at a fundamental level that is *the* limiting factor.

It is absurd to talk about qualks being transmitted – only the usual neural signals at the level of cognitive processing and communication are transmissible. Only active QPU contribute to the overall collective consciousness. The philosophical explanatory gap is in the scientific difference between *being* the QPUs and *not* being the QPUs.

Consciousness only exists *to* the conscious subject and *as* it *seems* to the conscious subject - it is ontologically *subjective* [189].

1.4 Activation of QPUs

QPUs have thresholds of activation. Once that threshold is exceeded, there is the respective conscious detection, no matter what happened before and how it happened. For the sake of organization, we can generally distinguish between exogenous and endogenous activations – signals initially from inside or initially from outside the brain, respectively (Figure 3).

It does not matter *how* a QPU is activated, as long as it *is* activated.

The correlates of consciousness through perception, perceptual illusions, recall, imagination, dreams, and hallucinations overlap. Furthermore, they do it *specifically* and in anatomical terms regarding the content subjectively experienced. This hypothesis explains why it is so natural to have both endogenous and exogenous activations simultaneously, since at a fundamental level the only thing that matters is that the QPUs end up activated. This hypothesis makes intuitive sense of hallucinations, perceptual illusions, and dreams at the level of consciousness: they simply involve activations of QPUs, and thus they are as *real* as it gets *to* the subject.

Hallucinations: The still intriguing phenomena of hallucinations involve activity in areas of the brain associated with normal perceptual processes, and often with similar contents overlapping [45]. With psychoactive substances, there are induced patterns of activation across the cortical areas where the hallucinatory percepts are generated [41][42]. Some seizures that involve visual areas in the occipital lobe are associated with elementary visual hallucinations [43]. Extrastriate activations correlate with visual hallucinations [44].

Selective activity in the auditory cortex correlates with auditory hallucinations in patients with schizophrenia [48]. Abnormal activity in the auditory cortex correlates with the buzzing, hissing, or ringing auditory hallucinatory experience in subjects with tinnitus [46] – something that Ludwig von Beethoven suffered from after losing his hearing and another good example of unwilled and uncontrolled hallucinatory experiences, which only exist *to* the individual. This condition is also associated with a significant reduction in the concentration of GABA in the auditory cortex [47].

Perceptual illusions: Color aftereffects correlate with activations in V4 [21]. Motion aftereffects correlate with activations in V5 [22].

Synesthesia: Individuals with synesthesia, who see additional colors associated with graphenes, are can probably attribute their symptoms to abnormal connectivity [49] and selective activations in V4 [50]. Synesthetes who additionally see associated colors while listening to spoken words also exhibit selective activation in V4, and interestingly no activation in V1. Normal controls, even after training periods on word-color associations, showed no such V4 selective activations while listening to spoken words [51].

Even *blind* synesthetes can still perceive colors while listening to spoken words and again show selective activity in V4 [52][53]. In synesthetes, we have a condition in which the perception of stimuli consistently and selectively leads to more QPU detection than usually elicited by those stimuli in other people.

Dreams: Often content-specific areas activated during the processes happening in dreams overlap with those activated during awake conscious states involving related contents and some attempts to decode them have already been made with some success [23].

Artificial stimulations: It has long been known that a variety of conscious phenomena can be elicited through even fairly naïve microstimulations of respective areas throughout the human cortex [24]. Furthermore, TMS stimulations over the visual cortex can induce phosphenes [25] [26][27] with shapes, colors, and textures, and even "visual echos" of visual contents experienced immediately before [28].

Phantom sensations: Through neuroplasticity, absent afferents can end up being replaced by neighbor afferents and the QPUs themselves being equally activated, leads to counterfeit conscious detections. Phantom limb pain is a well-known example of this [29][30].

Imagination: The generation of mental images is associated with activity in areas similar to those activated during direct perception [31][32][33][34]. In addition to visual perception, hemineglect can also apply to visual imagination [37]. rTMS can impair both perception and imagined mental imagery [38].

Even without being instructed to imagine and without active voluntary control, individuals imagine sensory percepts. Mere silent gaps during familiar songs trigger subjective auditory imagery of continuations that correlate with selective activity in the auditory cortex [39]. Similarly, in response to silent videos selective activity in the *auditory* cortex can even be used to decode *visual* stimuli using multivariate pattern analysis of fMRI data [40].

Consistent with our subjective experience of a greater potential for higher richness with full online perception compared with imagination, recollection, etc., not only does imagination use the same areas but also perception correlates with richer activation than the constructive imagination or recollection of the same objects [35][36].

But again I ask, what are QPUs?

2. From Biochemistry Up

2.1 What is it like to be a neuron?

There is no doubt that single cell organisms *sense* things. Also, since neurons are the only objects in the universe that we know generate actual consciousness, namely our own, it is an indefensible mistake not to be curious about the potential of these biological entities when trying to explain consciousness, especially given that since the birth of neuroscience, we are surprised over and over again by what we discover about neurons and the unknowns that we cannot even foresee.

It is fundamental for us to notice an obvious but often not present enough fact: neurons are not simply input-output converters. Between what comes in and what goes out, there are biological, living, autonomous, cells. No matter how densely packed the brain is, neurons are still individual organismal entities. Neurons are a very special type of cell, where excitability is just the beginning of that specialness. Even among themselves, they are incredibly diverse.

For short, it is often forgotten that between its synaptic inputs and its synaptic outputs, there is a special living biological entity. Thus, we often only pay attention to the *consequences* of what neurons do and not to what is happening *to* the neuron itself.

A neuron is already a biological detector. Then, only a capacity to produce a qualk is necessary. According to this hypothesis, the subjectivity of consciousness as well as the explanatory gap is at the *cellular level*.

2.2 The heterogeneity of neurons

More and more we are empirically and theoretically forced to rethink neurons and contemplate the potential of their full nature. Neurons are highly differentiated and distinct individual living units. This biological character is not only evident when comparing them with other cells but

also when comparing neurons amongst themselves. Traditional "bulk" DNA and RNA sequencing only provides an average of the contents of many neurons. According to this present hypothesis, precisely the elements of interest can be masked in the averaging.

Recent methodological developments now allow efficient sequencing at the single-neuron level [55][57][58][59][60][61][62][63][65][66][67]. The sequencing of individual neural compartments is also now possible [56]. The mere differential localization of RNA throughout the neuron is also a key factor to consider [64]. Already at the genome level, the differential and combinatorial expression of hundreds of effector genes define neurons with distinct characteristics. Even considering only what we currently know and can thus look for, a remarkable neural heterogeneity at the level of electrophysiology, morphology, and molecular biology (with mosaicisms in genomes, transcriptomes, and proteomes) is now more and more evident. Furthermore, most of the biological significance of that heterogeneity is still unknown.

Only in terms of olfactory receptors, we can already generate more than 1000 different varieties. Something similar in QPUs would not be abnormal. Alternative splicing, epigenetic regulation, posttranslational modifications, mobile elements [190], gradients [191], interactions of morphogens and other developmental events could be mechanisms that generate the differentiation and diversity of QPUs.

Attending to the characteristics of qualks and our increasing knowledge about the characteristics of neurons, the most obvious embodiments of QPUs should be single neurons.

2.3 QPU Mechanism

A QPU's felt detection is a *process*. Between primitive input signals and late resultant outputs involved in consciousness, there must reside a phenomenon limited in space and in time where an elementary conscious detection happens. Every single qualk we can experience must be generated *somewhere* and at *some point in time*.

It must offer the exact characteristics described for qualks. For example, it must be very fast turning on and off and meanwhile it must have some duration. It must also offer the substrate for the structured distinctiveness of qualks (Figure 1).

The mechanism of QPUs must have a genetic basis, be it more or less direct, otherwise natural selection could not have driven them into their present organization and diversity. The tree-like structure of qualks might suggest a natural evolution of qualks (Figure 1).

Biology is full of examples of cells that have capacities that others do not have. Neurons themselves have capacities that other neurons do not have.

This hypothesis suggests that the hard problem of consciousness should be solved at the qualk level and then at the full ensemble level of consciousness so that the problem of solving consciousness would no longer exist.

2.4 Sensing

Single cell organisms can sense. Some proteins can also sense - from receptors to allosteric enzymes, from voltage-gated channels to ATPases. It seems therefore parsimonious to place our focus within this range.

Cook and Damasio [14][68] have proposed that a basis for "irritability" and "sentience" at the neural level could be the fact that with the action potential, the finely regulated cellular system opens itself to the environment, causing abrupt diffusions of ions and inverting the membrane potential. However, the relevant part should be the *effect* of the action potential on the overall cellular entity and has in ways yet to be determined.

The initial axonal segment is also known to have different structures and compositions, depending on the neuron type [69], which are complex, robust, dynamic, very well regulated and functional beyond its common role of action potential initiation [70].

Obviously, the physical mechanism of the red qualk will not look red. And there is no *a priori* reason for a qualk to look exactly as it looks - the mechanism simply evolved into detecting in a way that ended up looking exactly how it looks.

Precisely because our ignorance about phenomena even at the biological level is still so big, claims about the quantum level seem precipitate and prone to self-confirmation biases, especially when considering that this deeper quantum level is not itself ontologically resolved and that compounding ignorance is antagonistic to the scientific method.

2.5 Where are QPUs?

This hypothesis explains why it has been so difficult to achieve the dream of pinpointing consciousness to a specific place in the brain: there is no single place to pinpoint the whole of collective consciousness into.

QPUs seem to be sparse – only a minority in each area – and dispersed – at many scattered places. Nonetheless, we are always talking about millions of them. The potential number of total QPUs, although very high in absolute terms, seems very reasonable considering the overall number of neurons in the areas of the brain involved.

The qualk hypothesis also effortlessly explains why the areas whose activities are most correlated with consciousness can be so scattered throughout the brain and nonetheless be naturally involved in the same collective consciousness.

There is a significant consensus that most areas of the brain do not directly generate consciousness.

Areas that probably *do not* contain QPUs are: cerebellum, hippocampi, amygdalae, basal ganglia, basal forebrain, V1 [73], prefrontal cortices [74][75][76][77] and everything from the spinal cord down.

Although we could find QPUs within the prefrontal cortex, based on the evidence we have, that does not seem neither probable nor necessary. The prefrontal cortex has a major role that is highly developed in humans, but regarding several processing and associative functions, from long-range coordination and task-specific control to working memory and attention – and not necessarily directly conscious detections themselves.

Areas that probably *do* contain QPUs are (Figure 4): somatosensory cortices [78][79], insulae [80][81][82][83][84][85][86][87], opercula, V4 [88], V5 [89][90][91], and some brainstem nuclei [92][93][94].

It should be noticed that this knowledge comes not only from passive recording studies but also from active studies with direct microstimulations that elicit corresponding conscious detections [2].

Different areas have different QPUs that are responsible for the generation of the different elements of consciousness.

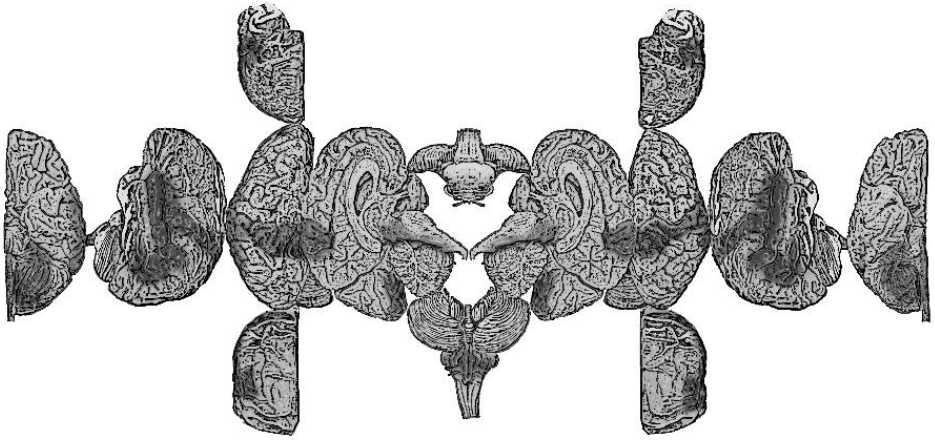

Figure 4. Brain multi-view with potential QPU areas highlighted.

2.6 The Pain Case Study

Distinct studies convergently point to the posterior operculoinsular complex (POIC) as the neural correlate of the painfulness of pain. The POIC has significant reciprocal connections with the S1, ACC, amygdala and prefrontal cortex – constituting the so-called "pain matrix". Activations in the POIC are proportional to the magnitude of painful stimulation [95][96]; the stimulation of the POIC produces the experience of pain [97] and the ablation of the POIC extinguishes pain, although ablation can also cause seizures [98].

2.7 Mistaking Consciousness

2.7.1 ***Fundamentally*** **Necessary vs.** ***Physiologically*** **Necessary:**

Physiologically necessary means that it is only necessary given normal and natural physiological conditions and set up, with the potential to possibly to do it in some other way. A heart is physiologically necessary but not fundamentally necessary. Another example is the fact that anesthetics work by ultimately hindering the necessary conditions for conscious detections. Obviously, this always affects more than just conscious detections themselves – at least it affects the output signals that are then absent. The physiological necessary background conditions (see Box 1) are very broad and can go from high-level prefrontal control down to glucose. Another important notion is that it is not enough to achieve a moment of activation of some remote QPUs or to be able to be stimulated by a neurosurgeon: to have normal consciousness one must be able to sustain *all* the necessary infrastructure, by *ourselves*, and *over time*.

2.7.2 What Consciousness Does *Not* Necessarily Involve – Like It or Not:

Consciousness does *not* necessarily involve self-consciousness, responsiveness, behavior, memory, cognition, intelligence, language, emotions, or the corpus callosum.

We now focus on another major thing also not necessarily involved in consciousness itself according to this hypothesis.

2.7.3 Consciousness is Not Unified:

The present hypothesis reinforces the well-established notion that there is no single central entity in the brain, be it a single element or a "unified whole", where everything converges and where a single central phenomenon is finally generated [99]. Here, it is applied to the last surviving phenomenon still loose enough to be seen in those terms: consciousness itself.

2.7.4 Homuncular Networks:

It is common to see complex conscious phenomena being described as having equally complex neural correlates of consciousness (NCCs), assuming that *everything*, as well as all the network interactions in between, is *in itself* generating conscious detections, and is thus a NCC, or that we have an irreducible obscure global entity and thus we can only ascribe a *homuncular network* character to the experience, in the spirit of the departed reticular theory.

Regarding this, Cajal commented, 106 years ago:

> "This is an idea which, appearing to us with the prestige of unity and of simplicity, has exerted and still exerts, a powerful attraction for even the most serene of spirits. True, it would be very convenient and very economical from the point of view of analytical effort if all the nerve centres were made up of a continuous intermediary network between the motor nerves and the sensitive and sensory nerves. Unfortunately, nature seems unaware of our intellectual need for convenience and unity, and very often takes delight in complication and diversity." [100]

In the history of neuroscience, no empirical support had been given to this format of hypotheses – much the opposite.

By the very definition of something complex, it usually involves *many* interactions between *many* parts. Even a focused and brief pain is a complex phenomenon that can involve many simultaneous components, from somatosensory perception and affective feelings to local associative processing, cognitive control and behavioral responses – with all of these evolving in time. It is acceptable, given the ignorance we still have regarding some phenomena we are studying, that we cannot further describe it, but it is not acceptable to infer mistaken conclusions based on the mere absence of knowledge.

2.7.5 Integration:

Integration of information is a very natural and general property of nervous systems. It is something far from obscure, common in artificial computational devices and common throughout our entire biological nervous system. Integration of information occurs from each neuron integrating post-synaptic information within itself to whole networks unconsciously integrating information from different sensory afferents. However, integration happens at the processing level, regardless of conscious detections themselves and without any necessary direct relation with them.

To claim that having fewer conscious detections is exclusively and sufficiently explained by less integration, one would have to prove that there is nothing *else* different as well, that a smaller integration itself does not *cause* something *else* that indeed is responsible for the absence of conscious detections and/or that the smaller integration itself is not *caused* by something *else* that indeed is responsible for the absence of conscious detections. These conjectural but very

reasonable indirect causal relations would indeed by definition generally make the variables correlate, but one should not conflate them – otherwise one would simply have committed a mistake worse than what would arise from taking consciousness as wakefulness or taking consciousness as responsiveness, since those are at least clinically understandable.

2.7.6 Connectivity:

Despite having a massive amount of connections between the two hemispheres disabled, there is not any sudden phenomenal scattering experienced by split-brain patients [101]. According to this hypothesis, only the opposite would be surprising, since conscious detections were never "phenomenally unified" in the first place. Obviously, there is a disintegration at the level of information exchanging, with each hemisphere not able to normally inform and control the other, which has strong implications in cognition and other further consequences, but it should not be mistaken for any abstract role in consciousness itself. For the sake of intuition, one could imagine artificially mimicking the lost inputs in each hemisphere and informational loss would be solved.

Additionally, Sperry himself concluded that: "It tells us further that the mediating cerebral mechanisms [of conscious experience] are in principle restricted and localizable and may in time be identified." [101]

Regarding the position claiming that the hemisphere without access to language modules is suddenly not capable of consciousness, that is simply committing the same naive mistake as claiming that a mute and paralyzed locked-in patient is not capable of consciousness – something that can have dramatic consequences.

Nonetheless, it is obvious that neural communication is a necessary *condition* for conscious detections. As an extreme, one could imagine every single neuron losing its inputs and by definition no conscious detection would be possible.

Regarding the fact that fronto-parietal, thalamo-cortical and cortico-cortical connectivity is decreased in several states when consciousness seems to be disabled, and the fact that naive TMS stimulations elicit activations that spread less prominently when consciousness seems to be disabled, we should keep in mind another fact: neurons have *inputs* and neurons have *outputs*. The presence of conscious detections also means the presence of *causes* and of *consequences* of the underlying signals involved if they are to have all their subsequent cognitive effects besides the phenomenal detections themselves.

If it appears that there are no conditions for effective connectivity, perhaps that is exactly why it is not possible to have conscious detections and reportability. By definition, if QPUs cannot be activated, it means that the processing and signalling neural networks where they are embedded are somehow not able to cause necessary activations in a normal physiological way. Moreover, if

QPUs cannot be activated for some reason, all of their efferent connections and all of the others that depend on them are absent or incapacitated as well. It would be surprising to not have necessary afferent causes and no capacity for activations but nonetheless activations or no activations with the respective efferent signals nonetheless propagating.

Specifically regarding the connectivity between more sensory areas and the frontal lobe, we should focus on the reverse direction in this topic of consciousness since it is well known that frontal support and control is generally physiologically necessary but obviously not sufficient. Specifically regarding TMS stimulations, it should be noticed that an unconscious brain-dead individual would have *even less* propagation than an unconscious individual in deep sleep or in a coma, and yet we would not conclude that the former individual is *even less* conscious than the unconscious latter.

2.7.7 The Persuasive Central Observer:

The assumption of a unification of conscious detections comes from the implicit pre-assumption of a single unified observer. That pre-assumption itself comes from a mistaken traditional model of ourselves that at the practical and macro level is usually a good enough conceptual approximation: that we are a single central point of view, as the *singular* word "I" itself implies. The main assumption of phenomenal unification does not truly come from our phenomenal experience – that only tells me that *I* experience *everything* and that each element of everything has its identity and contributes to a collective symphony of elements. This hypothesis simply recognizes the *I* as a collective and *everything* as collective. The unification and indivisibility of consciousness is not a phenomenal axiom but simply an unfounded conceptual assumption.

The burden is in showing the opposite, that somehow the *I* of consciousness is only a single, unified and indivisible entity, contrary to all that is known about the brain and to the fundamental discreteness of neural action.

There *are* several kinds of unity and integration, but in common *cognition*. Even there the existence of some kind of maximally unified or maximally broad single unified entity is not necessary – it simply is what it is and is useful for what it is. There is also unification and integration at the level of *knowledge* – indeed, most knowledge consists precisely of that.

2.7.8 Opposition to Previous Misconceptions:

It should by now be clear that this present hypothesis is in forthright opposition to previous hypotheses about consciousness *itself,* involving terms such as "indivisible", "unitary", "single", "bound", "uniform", "encompassing state", "maximally integrated", "irreducible", "field", "conceptual", "higher-order", "global", "whole-brain", "widely available information", "broadcasted information", "global ignition", and so on. Some of those properties do indeed exist

to a certain extent and some are even in processes related to consciousness, but they are not abstract features of consciousness itself.

QPUs' detections are the subjective qualks and that is it - there is no "and *then* they are unified into a single object to be presented to a single homuncular subject". That virtual additional step does not even ever appear as some potential solution for something necessary, as if conscious detections would not otherwise be possible or would not lead to exactly what we experience. We could even imagine what it would be to be conscious *without* that seemingly necessary additional step of phenomenal unification. Would we experience "gaps" between elements, and thus the gap elements themselves? Would we now experience our previous visual elements all shuffled, and thus meaning that there are simply *different* QPUs being activated? Would we only experience one element without being able to experience all the other "unbound" elements, and thus meaning that we simply have one QPU active and no other active? Would we not recognize single objects as single objects anymore, and thus indicating that there is some problem with our *cognition* and/or *knowledge* about the world?

In fact, according to this qualk hypothesis, one of the major advantages of consciousness is precisely the fact that it needs *no* physical integration and no global unit.

Additionally, we should notice the difference between unity and simple *coherence*. The apparent coherence of consciousness always exists to a certain extent since it is embedded in underlying structured cognitive systems, where coherence truly is.

It is curious to see how cognition, which is associative, interactive and emergent by nature, is nonetheless very commonly decomposed in elements, be them systems or bits, without any resistance of intuition, while consciousness, which is non-associative and compositional by nature, is nonetheless hardly, if ever, decomposed into their conscious detections, even despite continuous and diverse empirical and logical results pointing to that clairvoyant nature.

Potential partial explanations could be the following: there was no equivalent computer revolution to expose the tricks of consciousness; consciousness is too fundamental (as fundamental as it gets) for us to easily have the necessary cognitive unbiased distance to reflect upon it or to even have the desire to try it. We assume that we already have the correct model and the possibility of questioning it does not even come to mind, of questioning the traditional assumption of the indivisible subject with indivisible consciousness – even moreso given that it is a useful conceptual shortcut that works for all practical common terms.

This is not a question of *rejecting* phenomenal integration, but of not even having the need to ask for it in the first place. Several authors have previously at least argued for the existence of "several centers" for consciousness [102][103]. By the very definition of this hypothesis, it becomes obvious why with so much pressure from intuition there has been so much difficulty in trying to find a single, convergent and unified neural correlate of consciousness: it does not exist.

(*Continued on Part II*)