Global Consciousness-More than a Metaphor

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Abstract

Consciousness is an emergent phenomenon. Still, reductionist studies of neural activity are necessary for understanding consciousness. Consciousness is fundamentally describable as a continuum of the complexity of the interactions of components; varying degrees of consciousness arise at corresponding degrees of complexity. Hence consciousness is exhibited in all systems of dynamically interacting components. Of a high degree of complexity are populations of interacting humans, implying a degree of

consciousness emerging from this system, the global consciousness. Thus the complexity of human populations may be analysed for analogs of brain complexity, and vice versa. Attempts to identify analogs of the neural correlates of individual consciousness and the socio-economic interactions of humans may further our understanding of the nature of consciousness.

Consciousness as an Emergent Phenomenon

One of the prevailing theories of consciousness is that it is an emergent phenomenon (e.g. Baas and Emmeche, 1997; Trefil, 1997). Emergent phenomena are inherently irreducible, and cannot be understood by an analysis of the individual components of the system in isolation from their interactions with each other. Indeed, emergence theory has been regarded as the opposite of reductionism (Morowitz, 2002). Thus to understand consciousness, one cannot simply reduce the characteristics of consciousness to the activities of individual neurons in the brain-one must study the complex interactions among neurons and the properties exhibited by such collective interactions; that understanding is achieved by a holistic appreciation of those interactions (Baas and Emmeche, 1997; Capra 1996; Holland, 1998 et al).

This is distinguished from strictly functionalist approaches which say that consciousness is a function of computational complexity, implying that the computational complexity may be simulated by computers (Block, 2002). It may be argued that although the self-organizing properties of life and consciousness may be simulable by computer algorithm, simulations of sufficient complexity have not yet been achieved for any conclusions to be derived as to whether consciousness emerges (cf. Emmeche, Koppe, Stjernfeldt,1997). Further discussion of whether consciousness may be simulated by computer, is however, beyond the scope of this paper, for it is argued here that there is at least one other non-brain, non-computer, system of interacting components from which consciousness emerges, and which is eminently amenable to formal and empirical study.

Despite the inherent non-reducibility of consciousness, presumably some degree of reductionism is essential for brain studies (cf. Churchland, 1996). That is to say that individual neurons, or collections of them must be analyzed for their reactions to stimuli, internal or external. Of course many studies have been carried out over the decades from Golgi stains to electrophysiological recordings to neurochemical analysis to topological brain maps (Shepherd, G. ed, 1998; Hurdal, Kurtz, Banks, 2001) resulting in an understanding of neuron function and of specific areas of the brain. Even so, aside from the problems with the reducibility of consciousness (cf. Searle, 1997), there are practical and ethical limitations to more detailed study of synaptic interactivity: such detailed study necessarily involves a live functioning brain with its concomitant obvious ethical limitations (cf. Crick, 1994).

Significant advances have been made to isolate and reduce specific functions or properties of consciousness, such as the visual system and the relatively small number of neurons involved there (e.g. Crick and Koch). As well, there are regions or organs of the brain whose functions are well documented, the function of which can be definitely identified as being the source of certain behaviors or processes (e.g. the amygdala, cerebellum, Broca's area, etc.). Nevertheless, consciousness of the whole brain, though not necessarily a product of a complete brain (indeed split brains, or small portions of the brain arguably still exhibit consciousness (Puccetti, 1993)), can be understood more fully only by mapping the function and interactions of individual neurons, groups of neurons, groups of groups of neurons, and the integration of the collective whole (cf. Edelman, 1992).

Thus if consciousness emerges as a novel property of the interactions of neurons, then there must be some critical threshold of complexity of interactivity upon which it does so. (cf. Edelman and Tononi, 2000).

Physical Pre-requisites for Consciousness

With this view in mind, leaving aside for the moment the threshold of complexity necessary for consciousness to emerge, it is important to ask whether there are specific physical constructs necessary among a system of interacting components for consciousness to emerge.

At a basic level of brain function, we know that action potentials, mediated by electro-chemical neurotransmitters leap across synaptic clefts, and that billions of these transmissions occur constantly in the working brain (e.g. Rose, 1982). Is this specific synaptic activity, the exchange of neurotransmitters, therefore a necessary pre-requisite of consciousness, or is there something more fundamental involved? To answer the question, it seems that we must examine the essential nature of neural exchanges. At its most basic level, when a synapse fires in response to the receipt of an electro-chemical impulse, the synapse itself undergoes a temporary physical alteration; i.e. its physical condition and location in space are altered. In other words, the electro-chemical impulse has *influenced* the synapse to be altered in some physical way. The electro-chemical impulse therefore represents an information exchange which causes the receiving neuron to alter its physical properties. At its most fundamental level, therefore, it may be concluded that the actual synaptic activity and existence of neurotransmitters are not necessarily essential properties of consciousness, rather that the fundamental feature is the information exchange and the influence exacted to alter the physical properties of other neurons.

Are there other physical properties necessary for consciousness? Is there something in the very shape and constitution of neurons essential for consciousness? Sir Roger Penrose and Stuart Hameroff propose that axon microtubules bear essential features for quantum effects necessary for consciousness (Penrose, 1994; Hameroff, 2003). The theory expounded here is that whatever the properties of microtubules or other neural components are, they can yet be described more fundamentally in terms of information exchanges, and the rules that govern those exchanges; that there is nothing in the inherent physical structure of microtubules which is a necessary pre-requisite for consciousness because equivalent degrees of complex information exchanges should result in similar degrees of consciousness.

Nonetheless, while the view taken here is that the essential feature is information exchange and interactivity and the relative complexity thereof, the possibility that certain physical structures are essential for consciousness is not denied. However, if special physical structures are *not* essential and that the complexity of the information exchange and interacting components is the underlying feature of consciousness, then testable hypotheses can be derived from this which, based upon the success of such studies, may serve either to disprove altogether the necessity of specific physical architecture, or in the absence of contrary evidence, serve to support such a necessity. In other words, other non-neuronal physical systems-biological, chemical, or other artificially constructed systems may be studied for properties consistent with consciousness.

The Continuum of Consciousness

The central argument of this paper is that consciousness may be studied in other physical systems, be they artificial or naturally occurring. Indeed, it is argued here that for a proper theory of consciousness, it is *essential* that other systems be studied and tested for properties consistent with consciousness. Underlying this is the notion that consciousness does not emerge out of just any set of interacting components or degree of interactivity, but that it emerges only at a critical threshold of complexity (cf. Edelman and Tononi, 2000; Greenfield, 1995).

Then what systems of interacting components may exhibit the critical threshold of consciousness? For example, does a colony of ants exhibit the necessary threshold? Douglas Hofstadter (1979) writes in a Lewis Carollian literary "fugue", of an anteater which converses with a colony of ants, which Hofstadter suggests in his fictional account, as a whole exhibits consciousness. It is, however, counterintuitive that a colony of ants, while exhibiting identifiable emergent properties, meets the necessary threshold of interactive complexity for the emergence of the kind of consciousness humans or other higher organisms exhibit.

While ant interactivity may not meet the critical threshold of complexity for consciousness, there may well be other systems of interacting components which do meet this critical threshold, particularly that of interacting human beings. This does not preclude other biological systems from meeting the necessary threshold of complexity for consciousness to emerge, but intuitively one suspects that human interactions are yet vastly more complex than most other systems, even ones which might consist of higher *numbers* of interacting agents, such as schools of ocean krill or bacterial colonies.

Thus the principle espoused here is that consciousness is not an all or nothing proposition; that it exists by degree, may be mapped on a broad continuum, and that what is required is an understanding of the relative complexity of the interacting components of any given physical system - in the case of the human brain, its neurons. In all physical systems, formal descriptions of the complexity among groups of interacting components may be derived and plotted on a complexity continuum, and in the case of the human brain the unique properties associated with consciousness may be established as existing far to the right of the continuum (cf. Greenfield,1995). So, as the argument goes, along this continuum may also be plotted a variety of systems composed of any number of interacting components from two to billions. Obviously two interacting components gives rise to a low degree of complexity of interactivity, while billions of interacting components potentially gives rise to a very high degree of complexity, although, as noted, the criteria for complexity is not strictly high numbers of interacting components, but the rules which govern the interactivity (cf. Wolfram, 2002). Thus, along this continuum may be described the interactions between sub-atomic particles, through to the interactions among groups of human beings, the electrical circuitry of a computer chip, or the interactions of celestial bodies.

While this may be an unconventional approach to defining consciousness, it obviates a number of philosophical conundrums, such as whether consciousness exists only where there is subjective awareness; whether an ant is conscious, a rat, a pig or a dolphin; whether language is necessary for consciousness; whether individual humans may be able to attain “higher” states of consciousness. If complexity of interactivity is the fundamental characteristic of consciousness, then static things are not in and of themselves conscious, while many systems exhibit very low degrees of consciousness, while at a certain critical threshold of complexity degrees of consciousness such as human consciousness emerge. By extension, if a system of components *other* than a collection of neurons housed in a hard skeletal shell exhibit similar degrees of complexity, then it must be similarly conscious.

This should be distinguished from Chalmers’ (1996) panpsychist approach in which any material, object or system containing information exhibits conscious experience. At the risk of redundancy, while Chalmer’s approach is similar in concept, the underlying principle here is that of the relative complexity of the system of interacting components; that while there is a continuum of consciousness, only at a certain threshold of complexity does consciousness in the sense of self-awareness arise, although presumably “conscious experience” may be exhibited at lower degrees of complexity, while static objects exhibit no consciousness. And even static objects consist of atoms which in turn contain interacting sub-atomic particles. That being so, individual atoms exhibit a low degree of consciousness, while a stone exhibits virtually none because the atoms themselves do not sufficiently interact to give rise to any significant degree of consciousness except perhaps in liquid or gaseous form (cf. Bohm, 1980 and the concept of implicate order).

The key then is to identify the degrees of complexity giving rise to certain mental states, and the questions become: what is the degree of complexity of interacting neurons at which subjective awareness arises? What is the degree of complexity at which properties of visual images are bound or unified? What is the degree of complexity giving rise to REM sleep, to non-REM sleep, to being in a coma? This list goes on.

If the complexity of interactivities is the fundamental description of consciousness, then we can shift analysis to systems *other* than the brain. In particular this paper is concerned with the dynamic interactivity among human beings within their highly complex and integrated world-wide economy and communications network: the global consciousness. This leads to the hypothesis that equivalent degrees of complexity across different systems of interacting components (i.e. neurons to humans), give rise to similar degrees or states of consciousness.

The Measure of Complexity

Turning for the moment strictly to consciousness in the sense of self-awareness - call it "SA" consciousness - as a point, or region, along the continuum of consciousness.

If SA consciousness emerges at some critical threshold of complexity of interactivity among neurons, have we any idea what that critical threshold is?

It is argued here that the degree of complexity of the whole brain is presently considerably higher than the minimum threshold for SA consciousness to emerge. This can be demonstrated by patients having lost function of large portions of their brains while retaining basic characteristics of consciousness (Puccetti, 1993). Similarly, though the subject of some dispute, it is argued by some that split brain phenomenon indicates that each half of a divided brain exhibits independent consciousness (Puccetti, 1993; Penrose 1995 check). Daniel Dennett (1993) denies that the split brain results in two independent consciousnesses, primarily on the basis that the language function lies in the left hemisphere, which in turn is crucial for self-awareness (Puccetti, 1993). Without delving into the nuances of the issues and argument surrounding split brains and consciousness, there appear at least to be circumstances when less than completely functioning brains remain SA conscious (e.g. Alzheimers, aphasia, stroke victims, etc).

The point here is that we can begin by narrowing the degree of complexity of neural interactivity toward the critical threshold necessary for consciousness-sliding to the left somewhat on the continuum of complexity/consciousness. How far we can go is difficult to determine, but continued analysis of neural complexity over the next several years may allow us to arrive at an *arbitrary* level of complexity at which we can define SA consciousness as emerging. Arguably such an arbitrary level would entail a significant margin of error, but in principle we are defining consciousness according to a mathematical description rather than according to a vast panoply of competing assumptions and arguments about what consciousness is and what it is not.

The Fractal Nature of Global and Human Consciousness

It is important to distinguish between “global” consciousness and “human” consciousness. Here “global consciousness” refers to a literal consciousness which arises as an emergent phenomenon from the collective interactivity of human beings. “Human consciousness” is the *individual* consciousness we all know to exist in each of us.

While much has been said about the fractal nature of human consciousness (Satinover, 2001;Capra, 1996 et al.), little or none has been said regarding the possibility that the complexity of neural interactivity giving rise to human consciousness may be in form a fractal of the complexity of interactivity arising in other systems.

As indicated in preceding paragraphs, one prediction presented here is that we will find self-similarity in *complexity* of interactions on several scales of physical size and area of interactivity; i.e. The brain and all its myriad synaptic interactions are confined to a space the size of the average human head, while on a scale much larger, global consciousness arises in the space the surface area of the planet earth among interacting humans spread out over that surface. The implication of such a fractal theory of consciousness is that consciousness may emerge on much larger scales, or even smaller scales, assuming each system of interacting components reaches the critical threshold of complexity. This presents us with the possibility of actually measuring the physical exchanges of information over differing scales, assuming that "information" exchange is fundamental to the conscious process.

There are undoubtedly many problems to a proper quantification of the complexity involved at the various scales, perhaps the first of which is to define the proper boundaries of the systems to be studied. In the case of the human brain it is simple to confine the complexity of the brain to the interacting components within one brain itself. In the case of humankind, we may be able to confine the system to that of all humans on earth; i.e the system may be "operationally closed" in the sense of an autopoietic system (Maturana and Varela, 1980; Heylighen, 2003). However, if for example one attempts to correlate the complexity of synchronous behavior within crowds of people to the synchronous firings of specific sets of neurons in the brain, which crowds do we correlate to which sets of neurons? This paper does not propose an answer to the question; the intention is identify a category of study and hypothesis which may be ripe for more rigorous analysis.

The proposition here, therefore, is that corroborating evidence of a global consciousness may be revealed if the complexity of human interactivity occurs on fractal scales to other systems such as the brain or other physical systems. There are inherent problems in such analysis, particularly in isolating comparable systems, but the intent of this paper is to present possible avenues for further formal and empirical investigation.

Distinguishing Between Theories of Global Consciousness

It is important to distinguish the theory that global consciousness is an emergent phenomenon arising from the interactions among humans, from the notion of global consciousness as a form of cumulative consciousness as espoused by Teilhard de Chardin or “collective unconscious” proposed by Jung.

While de Chardin (1955) posited the notion that the relative complexity of a system was an inherent feature of consciousness, his notion of an evolution in consciousness through greater harmonization of collective thought diverges substantially from the theory espoused here. Indeed, the concept espoused here entails the notion that *any* kind of complex interactivity among humans forms the basis for the emergence of the novel properties of consciousness - such interactivity may include military planning and action and all of its consequences; morally “good” or harmonious interactions have no bearing on the existence of global consciousness.

Jung’s concept of the collective unconscious is not grounded in the concept of complexity (cf. Campbell, J., 1971). Furthermore, it is the position of this paper that the actions of the nodes (people, in the case of global consciousness) determine the nature of the “thoughts” of the global consciousness, and not vice versa (see subsequent discussion), as is perhaps implied in the concept of a collective unconscious and the archetypes which Jung theorized to arise universally.

Too, a strong case has been made that human and other organic networks comprise a global brain (Russell, 1995; Meyer-Kress, 1995; Capra, 1996; Bloom, 2000; et al.). However, much of the analysis has been largely confined to biological networks as analogs of anatomical aspects of the human brain, while the question of whether such analogous brains are conscious appears not to have been rigorously addressed, although it is an obvious implication of the proposition. Nor do such analyses appear to address rigorously the question of whether systems other than biological ones may be conscious.

Implications of Quantum Consciousness

If relative complexity is the measure of consciousness, then is this reconcilable with the Penrose and Hameroff (1994) proposition that quantum processes are involved in the leap from unconscious neural activity to SA conscious neural activity? Arguably the answer is yes, because the various quantum formulations themselves are in fact *descriptions* of complexity. These descriptions reveal a degree of complexity far higher than that exhibited by non-conscious entities, since we move from not only classical complexity involving neural interactivity, but to a combination of classical and quantum complexity.

It is argued here, however, that if relative complexity of neural processes lies at the heart of conscious processes, then a combination of classical and quantum complexity does not preclude the possibility of *equivalent* complex processes. A simple example is that there are a variety of routes one can take between Paris and Zurich, some longer than others. But the destination is the same in spite of a range of possible steps taken to achieve that result. A more interesting example is that Newtonian mathematics and Einstein's general relativity may be applied equivalently to describe accurately certain physical processes (at relatively low speeds) even though the mathematics involved are entirely different, and though the actual number of steps in arriving at the solution to our hypothetical problem may differ-the end result is the essentially the same (e.g. Hawking, 1983). A similar illustration is of two speakers of different languages, say English and

Greek: in order to describe the setting of the sun each speaker uses different syntax and grammar and obviously different words to convey essentially the same image. The illustration is also useful since Benjamin Ojemann (1983) showed that different languages engage different neural processes though presumably similar ideas may be communicated. Thus, while the interactions of *people* giving rise to a theoretical global consciousness may not involve quantum processes, the degree of the complexity of interactivity may be *equivalent* to the complexity exhibited in human consciousness.

One obvious counter argument is that quantum processes are physical processes and not emergent properties, thus distinguishing the quantum physical processes from the complexity of interactivity of neurons at the classical level. But even if quantum processes are involved in consciousness, it is the combination of these processes with the classical neural processes which give rise to consciousness, and the position that the quantum processes simply add to the physical complexity of the system is sustainable: consciousness is an emergent phenomenon of the combination of quantum processes and classical neural processes. Described in terms of complexity, this combination may be orders of magnitude higher than that achievable by human interaction or computer computational processes. This paper, however is premised on the argument that human interactivity at least has resulted in an equivalent degree of interactivity to neural processes.

The Problem of Medium and the Multiple Subconscious Hypothesis

Human beings of course perceive information from the outside world through various sense organs, and project information externally through gestures and vocalizations. If global consciousness is real, then how would it perceive external information or project it externally? There is obviously no evidence of any such organs of perception or any capacity for exhibiting information externally, but the view taken here is that such perceptions or capacity for communication are not necessary precursors or corollaries of consciousness, especially if consciousness exists to varying degrees: an ant colony, albeit relatively far down the continuum of consciousness, as a whole does not possess any such organs of perception or communication; farther to the right of the continuum, a person subject to sensory deprivation remains conscious while unable to perceive or communicate, albeit temporarily (cf. Freedman, Grunebaum, Greenblatt, 1961).

It is argued here that where a system of interacting components has significantly surpassed the minimum threshold for SA consciousness, communication occurs *internally* among a number of "sub-consciousnesses" within that system. The proposition here is that subsets of interacting components within a broader system can in themselves reach the critical threshold for SA consciousness (or perhaps some degree of consciousness slightly lower), and thereby communicate among one another through dynamically shifting subsets of interacting components. So in the brain, where the threshold for consciousness has been far surpassed, there is continual communication occurring among shifting subsets of neurons which subsets in themselves have reached the minimum level for SA consciousness, or a level of consciousness perhaps marginally below SA consciousness.

This is not a new theory. Greenfield (1999) speculates that multiple consciousnesses may exist, but that only one of which becomes the focus of awareness at any given moment; Edelman and Tononi (1998) speak of a dynamic core, constantly shifting throughout the cerebral cortex. Semir Zeki (1999) hypothesizes micro-consciousnesses arising primarily in the visual centers. Here it is suggested that these dynamically shifting sets of neurons are not necessarily unitary in time in the sense of only one being realized at given time, as proposed by Greenfield (1999), but are continually communicating with one another in a variety of combinations throughout the brain and engage in communication even when the *focus* of overall conscious attention may be elsewhere or even seemingly non-existent, as in non-dreaming sleep.

If each sub-consciousness is independently conscious, the question arises as to what it means to be conscious. According to conventional definitions, the hypothesized subconsciousness*es* cannot all be conscious at once because each does not represent a single focus of attention. For all subconsciousnesses to be individually conscious contradicts Greenfield's argument (1999) which says that while consciousness may shift throughout the brain, there can only be one state of attentional consciousness at any one time. However, no contradiction arises if we apply the theory that consciousness exists on a continuum and corresponds to the complexity of a given system's interacting components: any *subset* of neurons of sufficient complexity and whose neurons interact is itself conscious.

Moreover, the hypothesis here is that many of such neuron subsets are not simply situated *somewhere* along the continuum of consciousness, but in fact involve sufficient complexity in and of themselves to reach SA consciousness. With respect to the focus of attention, it suggested here that the combination of the subconsciousnesses in the brain gives rise to an overall consciousness which is more complex than the individual ones, thus serving to dominate the focus of attention. During the waking state, this combination of subconsciousness usually consists largely of the various perception related neural assemblies, but even this shifts considerably, as we all know by constant changes in our focus of attention.

One assumption arising from this hypothesis is that the "communicating" neuronal groups are not necessarily all of the same size or of equivalent complexity. This may be evidenced by continually varying wavelengths of brain electrical activity, among other things. Such shifting patterns in EEG activity are indeed seen (cf. Sabbatini, R., 2003 et al.), and the argument here that brainwave frequencies reflect in part communication between entire sub-consciousnesses is by no means an exclusive explanation, but an alternative or corollary explanation to current theories for the observed brainwave activity.

Regardless of the function of such sub-consciousnesses, it is the limitations in the study and identification of this shifting core that this paper is concerned with. If one primary feature of consciousness is the dynamic nature of integrated and differentiated groups of neurons (Edelman and Tononi, 2000), then some of the deficiencies in our current ability to study, identify, and quantify the precise nature of this dynamic core may be overcome by a study of analogous situations observed in human affairs. This is the central argument of this paper: a literal global consciousness emerges from the interactions of human kind and if regarded as a bona fide sphere of study, the study of individual human consciousness is complemented and supported by a study of the global consciousness, and vice versa.

Humanity consists of groups of all sizes, connected and communicating over a broad range of degrees; small groups exist in the form of clubs or social networks; larger groups consist of communities and cities; still larger are nations-each to a large degree autonomous, but all of which comprise "wheels within wheels", all within the overall world-wide human community, all of which engage in communication with one another to varying degrees and at varying levels.

Just as in the human brain, some of these working sub-groups may be sufficiently complex in and of themselves to exhibit consciousness, while others will not. What is proposed here is an interdisciplinary approach to the study of consciousness; that is to say that studies of individual human consciousness ought to include a study of the complexity of human affairs. We stand to learn much about the nature of consciousness generally by comparative analysis: rather like Monica Hurdal's flat brain topology (2002), the global brain is spread before us, easily accessible for observation and experimentation whereas the neurons of the brain in their living state are not.

What then are some of the analogous processes amenable to study? The following discussion is not intended to constitute a comprehensive analysis, but rather to present the kinds of analyses and hypotheses which may be pursued and to provoke more rigorous investigations on the subject.

Implications of Libet/Kornhuber

Although the subject of controversy, Benjamin Libet's experiments apparently demonstrate that neural activity precedes awareness of the willful desire to manifest physically the activity (Klein, 2002). Additionally, awareness of physical stimulus is delayed. If these situations are examined as analogous activity in the global consciousness, they suggest that 1) the interactions among people (analogous to neurons) are driven by *individual* conscious will and compose the emergent thought in the global brain, and not the other way around, 2) external stimuli in whatever form they may take to the global consciousness result in a delayed response in the activities of people. Of these two statements, the latter is intuitive, while the first not necessarily so, because intuition might suggest that somehow a conscious thought is first formed at the "meta" level of consciousness, and subsequently manifested in a response among the activities of neurons or people, as the analogy goes.

This is significant in the context of global consciousness because it supports the idea that the activities of people may be entered into of their own free will, which, when combined, create the emergence of a thought at the global level; that people aren't somehow governed by the overriding global consciousness, if it exists. If the situation was reversed - that is, if global consciousness was such that volition to act or manifest a thought came first in time followed by a neuronal response to that thought, this would be immediately problematic to any theory of global consciousness: it would suggest that the actions of people (as the neurons in the global consciousness) are governed by the will of the overriding global consciousness. Such a concept may support predestination or fatalistic theologies, but would be substantially less convincing in any scientific sense.

Similarly, the Libet experiment in particular suggests that neurons in the brain somehow possess some form or degree of free will of their own which governs the actions of the body, and not vice versa. We become aware of actions our neurons have already "decided" to engage in, and while we may think the action results from our own free will, the act has already been decided upon by the neurons before we become aware of them. Put simplistically, our neurons are smarter than we are. Likewise, in the context of the global brain, our activities, decided upon by us, allow for the emergence of thought at the global level.

Implications of Synchronous Firings as in Visual Systems

It is important to distinguish the perceptions of individual humans from any broad perception of sensory information by the global brain as a whole. Using visual perception as an example, the light received through one's eyes onto retinal cells and through to the oscillations of thalamacortical neurons (Edelman & Tononi, 2000) serve to affect that person's actions only. Many individuals may thus interact, but arguably there isn't a case where an external stimulus engages groups of humans whose function it is to "bind" the information received into a conscious experience within the global consciousness.

As discussed in the foregoing, if global consciousness exists as a closed system of interacting humans, it is apparent that it does not *naturally* receive or perceive external stimuli analogous to the perceptual stimuli received through the sense organs of an individual human being.

For example, one subject of considerable attention among neuroscientists (c.f. Chalmers 2003) is synchronous neuronal firings between the thalamus and the cerebral cortex are currently thought to be a critical neural correlate to visual perceptions (e.g. Crick and Koch, 1990; Edelman and Tononi, 2000). These synchronous firings offer an explanation to the "binding problem", or unification into a single conscious experience different visual features such as color and shape which trigger firings in disparate regions of the brain (e.g. Crick, 1990).

Being well-studied, this presumably would be an area ripe for investigations into analogous human activity. Yet arguably because there is no analogous visual organ in the global brain, the binding problem and indeed all aspects of perceptual consciousness are either excluded from the proposed comparative analysis and/or support arguments rebutting the very proposition of global consciousness.

Nonetheless, situations analogous to perceptions of external stimuli do exist at the collective human level, although not necessarily naturally so. Humankind has artificially created the function of sensory perceptions by designing large telescopes, radar, spectroscopes and a variety of other perceptual instruments requiring the coordination of hundreds and perhaps thousands to interpret and disseminate the information throughout the global population. There seems no reason why such artificially constructed perceptual instruments ought to be excluded from comparative analysis, since such instruments are a result of the very complexity among human interactions from which global consciousness emerges; sufficient complexity begets further complexity, as is evident from our own brain's capacity to learn continuously.

Thus it may hypothesized that there are measurable synchronous oscillations occurring between groups who operate the sensory instruments (e.g. astronomers, engineers, computer technicians etc.), those receive and interpret the data (e.g. astronomers, physicists, etc), and those who disseminate the information publicly (e.g. also the astronomers and physics, but also journalists, public relations personnel etc.).

One means of testing the hypothesis that something equivalent to 40 hertz oscillations occur in human activity is by careful observation of the interactions between the actual groups involved. Another, perhaps simpler means, is by computer simulations of actions resulting from the discussed receipt of external stimuli. As an example, designating the Hubble telescope as the source of external stimuli and the hundreds of astronomers, engineers and technicians involved (Chiasson, 1994) as the group receiving and interpreting the data; the administrators, public relations officers, and press as the information disseminators, rules may be gleaned as to the relationship between the technicians analyzing the data and those disseminating the data, from which a computer algorithm might be designed.

Applying the proposition that simple rules result in complex behavior (Holland, 1999; Wolfram, 2002 et al.), presumably the rules could be relatively coarse-grained and complex behavior and/or specific patterns would be observed without the need to model the minutiae of interactivity between groups. It may be borne in mind that the scale of interactions is different temporally and spatially from that occurring among neurons in the brain, so some oscillation frequency other than 40 hertz may be predicted. As hypothesized above, the scales may be fractal in nature both temporally and spatially, and predictions may be made on that basis.

The actual transmission of information is perhaps roughly equal, given that in the brain the processes are electro-chemical, while in the world information transmission occurs almost as rapidly. But if transmission in both cases are roughly equal, the speed of information *processing* is not, which occurs more rapidly in the brain. In the case of human information processing, in many circumstances it takes significant amounts of time for decisions to be made on the basis of information received. Thus, in determining whether certain human information exchange oscillates at frequencies equivalent to certain brain processes, one factor among many, no doubt, to consider is the rate of information processing.

While, as stated earlier, a detailed discussion of computer simulations is outside the scope of this paper, certain computer simulations may be useful in corroborating or identifying properties of human interactivity which may be analogous to neural architectures. As one example among many, Lago-Fernandez and colleagues (2000) found that simulations incorporating small worlds topology yielded results closely replicating the 20 hertz oscillations in a locust's olfactory neural system. Small worlds architecture exists in human interactivity (cf. Buchanan, 2000; Watts and Strogatz, 1998), and it may be that scaled or similar oscillations await to be identified in human interactivity.

The Problem of Language

It has been argued that the capacity for language is an essential feature of higher consciousness (Edelman, 1992 et al). Dennett (1992) says that consciousness does not exist without it. However, it is argued here that language is unnecessary for SA consciousness, a view supported by many (Churchland, P.S., 1996). But the principle problem posed here is that similar to the limitations a global consciousness might have in terms of perceiving external physical stimulus, so does a global consciousness have no physical organ of expression in the way that vocal chords or body signals provide this medium in humans and other organisms.

The absence of a global consciousness' capacity either to respond to external stimulus or express itself may be fuel to the camp who would ask what it means to be conscious if there are no mechanisms for perceiving the world or for communicating with it. Neither of these are necessary if the continuum approach to consciousness is taken. Moreover, to repeat, the position taken here is that communication occurs internally to the global consciousness between and among the disparate and shifting groups sufficient in themselves to constitute sub-conscious entities. The view that the holistic human experience consists largely of brain states independent of and not necessarily caused by external stimuli is one gaining acceptance. Churchland, P.S. (1996) refers to the concept as "endogenesis" (cf. Merzenich and deCharms, 1996).

Non-perception Related Consciousness

It may be argued that consciousness does not exist without awareness or perception of external sensory stimuli, or that if there are identifiable aspects to consciousness *other* than that which corresponds to perception of the environment, then any such other aspects of consciousness only arose as a result of millions of years of brain evolution which started with simple stimulus/response levels of awareness; that consciousness cannot have arisen without sensory stimulus to begin with.

However, here again it is argued that such organs of perception and the neural correlates of perception are not *essential* components of consciousness if consciousness is viewed as arising where ever sufficiently complex interactions occur. The human brain may have evolved to its current level of complexity through millions of years of sensory input, but this does not preclude the possibility that equivalent degrees of complexity may arise through very different processes. Thus human societies and/or other complex systems have developed equivalent degrees of complexity through processes quite distinct from evolution through continuous perceptual stimuli.

If that is so, then the question arises as to what non-perception related brain processes are analogs of global consciousness. As argued above, consciousness is not an all or nothing proposition; that emerging from brain processes are numerous sub-consciousnesses, or micro-consciousnesses (Zeki, 1999). These sub-consciousnesses are in continual communication with one another, independently of the focus of consciousness; i.e. that which holds our immediate attention. The analog of these sub-consciousnesses is simply large sub-groups of human populations. For example, the population of the United States, numbering nearly 300 million, is a complete unit unto itself of highly complex economic and social activity. The complexity of interactions among this discreet population unit may itself be sufficiently high so as to comprise the foundation for an emergent global consciousness. Similarly with the populations of China, or Russia, or many others.

Communication occurs among all of these discreet populations, together comprising the totality of global consciousness. These populations engage in communications with one another in countless networks, similarly to neural assemblies, and one may imagine a very large number of such intersecting subsets, rather like a complicated Venn diagram.

It is hypothesized here that it may be possible to identify analogous patterns of interactivity among these human populations to theta, delta, and other non-beta/alpha brain frequencies. These frequencies in particular are identified because of the problem of the absence of sensory organs and perceptual processing associated with the global consciousness (except for perhaps artificial perceptions), as discussed above. So, as this hypothesis goes, attempts to identify global consciousness/individual brain analogs, should be approached on the premise that perception related analogs may either not be found or be more difficult to find; that it is the internal, non-perception related consciousness of the human brain which is the broad analog for study.

So, while we may seek analogs to neural processes in human processes, the converse is also possible: analogs to human processes may be sought in neural processes, which in turn may provide a deeper understanding of individual consciousness. The interdisciplinary study of global consciousness and individual consciousness may provide a broader understanding of the nature of consciousness.

Other Analogous Situations - Hypersynchronous Processes

Edelman and Tononi (2000) suggest that while synchronous oscillations of specific populations is a key feature of consciousness, *hyper*synchronous neural activity results in a loss of consciousness. Such hypersynchronous activity is, they point out, evident during epileptic seizures, when temporary losses in consciousness are experienced. Hypersynchronous behavior of this nature exhibits low integration and differentiation, and therefore low complexity (as does simple random neural activity).

Arguably large human populations engaging in sameness of activity exhibit similarly low degrees of complex interactivity. So, for example, low integration and differentiation and hence low complexity occurs in situations where thousands march in uniform fashion, bow simultaneously toward Mecca, or sit silently in front of the television. On the contrary, where there is *dynamic* integration between synchronously behaving populations, as in the binding feature of similar neural processes, arguably complexity is increased.

It is emphasized that these analogous situations are presented to provoke more detailed inquiry and analysis. Moreover, as outlined by Chalmers (1998), there are several competing theories as to the neural correlates of consciousness, and it is argued here that each of these ought to be investigated for analogs in human global interactivity.

It is acknowledged that the examples presented here of analogs in human interactivity of the neural correlates of human consciousness may entail certain logical and empirical problems. But the premise is that if consciousness is defined as a broad continuum of the complexity of interactions, then it is validly argued that global consciousness arises from the interactions among humans. If so, then the processes giving rise to global consciousness are likely to be similar to the processes giving rise to brain consciousness, and valid comparisons may be made as between the respective systems.

Conclusion

This paper suggests that a) consciousness exists by degrees according the complexity of the interactivity of the components of a physical system, regardless of whether the system is biological or otherwise; b) the complexity of neural processes and that of other systems can be mathematically formalized and compared; c) consciousness studies can therefore be broadened to include an analysis of systems other than the brains of higher organisms; d) such studies of other physical systems can be correlated and corroborated with brain consciousness studies, and testable hypotheses can be derived by which a broader understanding of consciousness as a universal phenomenon may be achieved; e) that such studies and tests are best carried out on human populations because of their amenability to study, and because studies can be carried out on the premise that the interactivity of human populations has reached the necessary threshold of complexity for higher consciousness to emerge; f) finally, that such studies may assist in overcoming the practical and ethical limitations currently experienced in the study of human consciousness.

That the interactions of humans results in a unified conscious entity may be a difficult conclusion for mainstream science to accept, but we can avoid the philosophical and theological implications of such a concept if we found the concept on principles of mathematical complexity. If rigorous investigations reveal verifiable and sufficient similarities between the interactions of humans and the interactions of neurons, perhaps then we may consider the philosophical and theological implications of such studies.

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