QUANTUM FLUCTUATION FIELDS AND CONSCIOUS EXPERIENCE:

HOW NEURODYNAMICS TRANSCENDS CLASSICAL AND QUANTUM MECHANICS

Alex Hankey

ABSTRACT: Subjective experience presents a conundrum to science. Those convinced of its reality recognise that it requires explanation, but that classical physics is unable to provide one. They often assume that, as a consequence, quantum mechanics must provide the basis for a theory. However, consciousness seems able to reduce quantum wave packets, a process that quantum wave functions cannot accomplish, ruling out that approach. Recent research suggests that fluctuations at critical instabilities provide a non-reductive, double aspect information theory, i.e. properties identified as necessary aspects of any theory of experience. Due to complexity, biological systems support critical instabilities. Complexity means that they obey principles like Edge of Chaos and Fractal Physiology, and that organisms are not mechanical systems. Critical instabilities are in turn supported by the principle of Self-Organised Criticality, well known to be exhibited by neuronal cortices. The neurodynamics underlying experience and consciousness encompasses critical instabilities on networks of neurons. Due to a famous theorem from material science, the spin-glass neural network isomorphism, such instabilities can have arbitrary complexity, and can model and control genetic networks, well known to function at the Edge of Chaos. Here we show how information on sensory pathways enters conscious experience by means of the process of Inhibition of Lateral Inhibition identified by Karl Pribram, and making possible holographic representation of sense information.

KEYWORDS: Experience; Criticality; Experience Information; Neural Networks; Sensory Pathways; Holographic Paradigm

INTRODUCTION

Science has long treated the subject of phenomenal experience as an insoluble mystery, and been hostile to attempts to provide a scientific explanation for it. Part of the problem has been a misunderstanding of the word 'objective': science must remain objective. Some scientists interpret this to mean that science should therefore not be concerned with any question of how the world of subjectivity is supported in biology. But that constitutes a misunderstanding of the word 'objective', which really means that scientists should remain intellectually detached, and not be too attached to their preconceptions, when science progresses in ways that change them.

Until quite recently, the conundrum presented to science by the phenomenon of experience was considered insoluble. Although many were convinced of the reality of experience and recognised that its explanation should be considered a potential scientific problem, they also recognized that neither classical physics not quantum physics were able to provide it. (Chalmers, 1997b) Classical physics describes entities in purely objective terms and is a non-starter. Quantum physics on the other hand seemed to involve consciousness at its foundations, and seemed more promising. This is because, in quantum physics, it was recognized that the phenomenon of 'the collapse of the wave function' requires an observer, with the ability to subjectively record and report an event. However, if an observer's consciousness is to collapse a wave-function, or put more accurately, 'reduce a packet of wave functions' (shortened to 'reduce the wave packet') then *something other than quantum wave functions must be involved*, because quantum functions cannot accomplish this.

In the 1990's the situation completely changed when a student of philosophy, David Chalmers, published first his PhD thesis, a series of papers in the then new Journal of Consciousness Studies (Chalmers, 1995, 1996, 1997a), and then a book (Chalmers, 1997b). Next the scientific community held a conference on his new approach, and all the comments and Chalmers' responses were edited into a book by the JCS Editor, Jonathan Shear (Shear, 1997). Chalmers identified the phenomenon of experience itself as the main challenge confronting any aspiring theory of consciousness, and set out four conditions that any physical theory of experience would have to satisfy, two of which are discussed in the next paragraph. (Chalmers, 1997a, Reprinted in Shear, 1997)

First, he posited that the experiencer, the subject, should be considered as fundamental a concept in the world of science as mass, or the electric charge. It should be accepted as beyond explanation, and as valid as other fundamental elements in physical science. Chalmers also pointed out that the theory should be non-reductive, and that it should be an information theory where the information possessed a double aspect enabling it not only to represent information, but also to specifically pertain to subjective experience. In the last few years, just such an information theory has been discovered, moreover one which applies in biological regulation.

COMPLEXITY BIOLOGY

Complexity biology dates from Stuart Kauffman's studies of genetic networks in the 1960s (Kauffman, 1969), when he discovered that they operate under a regime that he named 'The Edge of Chaos'. Genes are expressed not singly, but in 'loops' containing several genes, all of which are expressed at the same time. Such 'loops of genes' can induce or repress the expression of other loops of genes. What Kauffman discovered was that especially realistic conditions arise when each such loop acts on average on precisely two other loops of genes. If the number is less than two, then the system becomes static, with little or no change possible in which loops are being expressed, while when the number is more than two, the whole thing becomes unstable and chaotic, with genetic loops constantly being switched on and off. The number two, at the edge of the chaotic region, was the only coupling number, for which the realistic kinds of biological seemed to result. Ergo: loops of genes formed networks of genetic loops switching each other on and off, and such 'genetic networks' seemed to function at The Edge of Chaos. Thus was born the first principle of complexity biology (Kauffman, 1996).

With Edge of Chaos come other properties. Physiological systems do not give fixed responses to a series of fixed stimuli, they rather respond with a distribution of responses; most unusual distributions at that. Rather than obeying statistical distributions of the usual kind, they are fractal distributions, giving rise to the general name, Fractal Physiology (Bassingthwaite, 1994). Such distributions are characteristic of systems at instabilities, meaning that some parameter of the system is no longer held firmly at a fixed value. Instead, like the density of a liquid at its critical point, some parameter of the system has become unstable, with its value fluctuating violently in a series of critical fluctuations. The advantages of this for regulation of the system turn out to be profound and to give physiological systems otherwise impossible sensitivity and flexibility of response. Variability of response also means that a population of organisms is more likely to survive a previously unencountered challenge in environmental circumstances. Whereas a population giving a fixed response would in all likelihood be annihilated by such a challenge, a population giving variable responses would be more likely to survive: if only one organism made a viable response, the entire population would be regenerated; furthermore, it would contain knowledge of how to respond appropriately the next time that challenge was encountered.

The property of offering a fractal distribution of responses to a series of fixed stimuli results from the control structure in question being located at an instability; the locus of control is an instability, a condition that is not difficult to arrange, since critical instabilities occur naturally in cybernetic control systems, as Norbert Wiener who formulated their theory in his book, Cybernetics, was first to point out (Wiener, 1948). The advantageous property of criticality is maintained in biological systems by a principle which maintains it: Self-Organised Criticality (SOC), which forms the fourth and final principle of complexity. (Bak et al., 1987)

The physics of critical instabilities is dominated by critical point fluctuations. If the locus of control of the regulatory system of a particular organism function is at a critical instability, then its physics is governed by critical fluctuations. If another system needs to communicate to that system, it must utilize a language appropriate to the phenomenon of instability (Hankey, 2014). It is now known that the information theory available at instabilities is not that of digital information, applying at all points with stable physics. Physical excitations at instabilities possess a very different information structure; and, serendipitously the new structure has all the properties posited to be necessary for a theory of consciousness by David Chalmers.

First, fluctuations at critical instabilities possess very high coherence lengths, keeping them so integrated that their physics cannot be reduced to individual excitations. Such potential reduction may apply to ordinary quantum theory. but high levels of integration resulting from very long coherence lengths, mean that systems at criticality cannot be reduced to component excitations; they are non-reductive. (Hankey, 2014)

Second, the information structure can be shown to have two components – the double-aspect structure predicted by Chalmers. Demonstration of this property is simple. Consider the example of fluid flowing down a tube. Under normal circumstances a fluid flows with constant speed and direction at each point: the flow at each point is defined by a single vector, <------------. However, at higher values of the pressure gradient, vortices form and the fluid no longer exhibits unique flow vectors at each point. At the critical point, characterised by a special value of 'Reynolds' number' for the system, vortices are just unable to form, though they are present as it were, at an unmanifest level, at every point in the fluid. In this case the single vectors representing the flow become mixtures of single flow vectors; more precisely, an infinite number of single vectors, all stitched together by a vortex that is infinitesimal and unmanifest. This structure can be represented by <=========**O**. While the previous structure possesses only a single aspect – the vector itself, with length and direction – the new structure possess two aspects, the mixture of vectors <========, and the vortex loop, **O**. Clearly, this information possesses the 'double aspect' structure proposed by Chalmers. (Hankey, 2015)

The novel structure of information may be hypothesized to apply to all systems at critical instabilities, i.e. to biological instabilities as well as flow instabilities in fluids. This hypothesis transforms the structure into an ideal candidate to represent information in subjective experience: fluctuations at critical instabilities support a kind of information that is non-reductive, and which also possesses a double aspect, both the properties identified as necessary aspects of any information structure for it to support experience.

EXPERIENCE

How can nervous systems exhibit critical instabilities? For if they can do so, then the new form of information becomes a candidate to support subjective experience of the kind found in animals, including humans. The first step in showing that this may be possible comes from the theory of ferromagnets. Here systems of spins interact and align parallel only so long as the random effects of heat do not disrupt them too much. More complicated kinds of interaction make the spin system capable of more complicated kinds of magnetic phase transition, and correspondingly more complex kinds of critical phenomena, such as tricritical points and critical points of yet higher order. (Chang, 1973; Hankey, 1973; Harbus, 1975). Eventually, the kinds of magnetic critical point culminate in forms that can model and control the entire structure of critical phenomena occurring in genetic networks, i.e. arbitrarily complex kinds of critical point. This requires a series of randomly arranged crystal lattice with arbitrarily long-ranged interactions, a system known as a spin-glass.

Serendipitously, material science has stated a famous theorem, that a network of neurons has identical properties to a spin-glass (Amit et al, 1985), and that the two can be considered entirely equivalent: the spin-glass neural network isomorphism. This has the important consequence that the physics of information derived for critical instabilities, such as those in fluid flows, fluid densities, or in magnets, also applies to instabilities on networks of neurons. When life hit on cells with neuronal structures as suitable for organism control, doing so because networks of such cells could control cells' genetic networks, networks of such cells exhibited information structures at their critical instabilities, which could support subjective experience.

The conclusion for neuroscience is that experience is supported by neurodynamics of critical instabilities on networks of neurons, a highly unusual aspect of neuron function scarcely considered at all previously in the quest to understand consciousness.

HOLOGRAPHIC PARADIGM

Having identified candidate structures for the actualisation of experience in nervous systems, the question arises as to how sensory information can be encoded in such states. How can the manifestly digital information, which is transmitted along the neuronal axons of the sensory pathways in the peripheral nervous system, be converted in experience information on the networks of neurons forming the cortices of the central nervous system? There can be no doubt that in the sense organs, and on the sensory pathways and the original encoding on the sensory cortices, sense information is represented in digital form. In the minds of many neuroscientists, this constitutes a major reason for them not to believe in subjective awareness as an aspect of brain function. (See Shear, 1999) However, they can only hold such beliefs (or non-beliefs) by neglecting a central aspect of the neuroscience of the registration of sensory information in consciousness, i.e. its coming to experience.

Stanford neurosurgeon Karl Pribram who spent many years studying pathways of information in the brain, concluded that sensory information is not registered in consciousness immediately it arrives at the cortical area for that sense, i.e. the visual cortex for vision, auditory cortex for hearing, and so on. Pribram showed that sense information is only registered in experience following a special process in the cortex concerned, known as the Inhibition of Lateral Inhibition (ILI). First the information is registered in the cortex, where it is held and confirmed by the process of lateral inhibition, which keeps it well defined. Then it is allowed to spread over the entire cortex by ILI. Pribram showed that only when ILI has occurred does the information register in experience. (Pribram, 1981)

And what does the ILI process accomplish – the lateralization of the information might be expected merely to wipe the slate clean for the next piece of information to appear. For our purpose, the observation that ILI is required to register information in experience is vital, first because it means that the form of information in the sensory cortex, digital information, is *not* the form of information in experience, and second because just such a linear transformation would be required to convert the digital information in a sensory cortex into the kind of information, by which a critical instability on the cortex could represent it in experience.

Karl Pribram was partly directed to the investigations leading to his conclusion by observations that *information in experience could not be found in any particular place in the cortex*. This suggested that such information was contained *all over the cortex*, a form only made possible by a process of linear transformation, similar to that by which a Fourier Transform converts a digital picture into a hologram. Karl Pribram's concept was therefore called, 'The Holographic Paradigm', and written up in a series of essays published by Ken Wilbur as a book of that name (Wilbur, 1982).

CONCLUSIONS

Nervous systems are admirably equipped to support experience. The phenomenon is made possible by their ability to support critical instabilities, since the structure of information at critical instabilities satisfies all the conditions laid down by David Chalmers: the information structure is non-reductive (due to its long range critical correlations), and is a double aspect structure due its form as <=========**O**, containing both an internal information loop, O, and a mixture of information vectors, <=========.

Information from sensory pathways, stored as digital information in digital cortices, is converted into experience information by a general linear transformation known as inhibition of lateral inhibition (ILI) in its sensory cortex, known to be the final information processing step on the pathways bringing information from the five senses to conscious awareness.

At the same time, the actual subject cannot be defined, and must be considered a fundamental concept in its own right. In the same way that electric charge is what couples matter to electromagnetic fields in Maxwell's equations, and mass is what couples matter to gravitational field in Einstein's field equations, the subject is the entity that couples to the universe in experience information.

alexhankey@gmail.com
Swami Vivekananda Yoga Anusandhana Samsthana
Bangalore, India

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