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Peak Experiences in a Consciousness Landscape

Report on The Science of Consciousness Conference in Interlaken, Switzerland, 2019

1. Introduction

The Science of Consciousness (TSC) 2019 was the 26th international interdisciplinary conference in the series that started in Tucson in 1994. This one was held in late June in the beautiful Swiss town of Interlaken, between two lakes and surrounded by high alps. The local organizer was Harald Atmanspacher from Collegium Helveticum in Zurich, assisted by the 'eternal' main organizer, Stuart Hameroff from the Center for Consciousness Studies in Tucson.

There was no special theme for this conference, but I agree with the introductory comment in the abstract book: 'Despite remarkable empirical and theoretical progress, consciousness is not understood yet, and therefore the field will benefit from a healthy scientific attitude that includes openness to multiple perspectives.' This was certainly applicable here.

The beautiful alpine landscape provided a perfect setting for the conference, but the unexpectedly hot weather made it hard to concentrate on and contemplate the deep questions discussed. Yet, the organizers had done what they could to make the conference welcoming and inspiring for the 620 participants from about 30 countries.

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There were in total 24 invited talks in nine plenary sessions, 105 oral presentations in concurrent sessions, and 220 posters — on topics such as connectomics, placebo research, first-person experience, anaesthetics, psychedelics, plant cognition, quantum biology, dual-aspect monism, bistable perception, insight, religious studies, evolution, and language. More details on the conference, including video recordings of the plenary talks, are available on www.tsc2019-interlaken.ch.

This will be a very subjective report, where I have cherry-picked among the talks I attended, primarily focusing on the plenaries, but with some visits to concurrent sessions. In addition, I will not give equal amount of space to all the presentations I refer to, and apologize if anyone feels mistreated that way. It also goes without saying that the report is biased with respect to my own research interests, as a biophysicist working with neurocomputational models of decision making, based on mesoscopic neurodynamics.

Inspired by the surrounding alpine landscape, I think it could serve as a metaphor for the mental landscape and intellectual challenges we have to climb when trying to understand the ancient conundrum of consciousness. The perspectives provided by various research areas can then be likened to different alps, with rather deep valleys between. Somewhat arbitrarily, I will structure my report around three major peak perspectives, Physics, Biology, and Metaphysics, where I have roughly and not chronologically grouped the various presentations.

2. The Physics Alp

Quite a few presentations were essentially devoted to quantum physics, which plays a central role in TSC conferences in general, and perhaps this one in particular, primarily due to the interests of the organizers. So let's start by climbing the Physics Alp.

Quantum mechanics (QM) was introduced and discussed already in the in-depth workshops. For example, my Finnish friend Paavo Pylkkänen (Helsinki University) organized a workshop on the somewhat unusual topic of 'Free Will and Quantum Agency'. Its main idea was to explore whether quantum indeterminism is sufficient to account for human free will, in particular with regard to the collapse of the wave function caused by the measurement of a conscious agent.

In the plenary session on 'Artificial Intelligence, Computation, Physical Law, and Consciousness', chaired by Stuart Hameroff, the principal speaker was **Roger Penrose**, who pioneered in the field of consciousness research with his book, *The Emperor's New Mind*, published 30 years ago! This was already before Crick and Koch (1990) opened up a neuroscientific approach to the brain–mind problem.

I first met Penrose at a workshop in 1993, in Abisko — a remote place in the arctic region of northern Sweden — where one of the highlights was a discussion between Penrose and Daniel Dennett on the view of consciousness as either computable or non-computable. Another highlight of this meeting was the birth of the Orch-OR (orchestrated objective reduction) hypothesis of consciousness, which was carved out by Penrose and Hameroff, who also participated in that Abisko workshop. Hameroff has described their lengthy discussions there in the book *Mind Matters?* (Hameroff, 1997).

In 1993, Penrose used good old overhead (OH) projector slides for his presentation, which he has used ever since, but not at this TSC conference. Instead, he had made a PowerPoint presentation of his OH slides, 'because they were too heavy to carry around'. Penrose started off by restating his main idea that consciousness depends on physics we don't yet know. He continued by asking whether we can ever hope to understand consciousness in terms of either, (1) computation, (2) existing science, (3) extended physical worldview, or (4) something beyond science. His own answer is that (3) is required, with arguments from philosophy, mathematics, physics, biology, and psychology.

Penrose put a focus on *understanding*, and showed a figure where an arrow pointed from *awareness* (which Penrose appears to use synonymously with *consciousness*), to understanding, and another arrow from understanding to intelligence, also with backward arrows, showing that all of these capacities depend on each other. Hence, if understanding can be shown to be beyond computation, then intelligence is not a matter of computation.

A natural follow-up question is whether a computer could *understand*. Of course, Penrose replies ‘No’ to this question, and to demonstrate this he had constructed a ‘stupid’ chess position (which he showed for the audience) that ‘Fritz’ — or any other chess computer — cannot win, because computers don’t understand chess. The position is not part of the ‘experience’ of the computer. Similar issues can be demonstrated with games such as Go, which AlphaZero can’t solve, for the same reason. Mathematical or other human understanding are examples of non-computatable processes, and so is human consciousness. Non-computability may well be a feature of all forms of consciousness, which would imply non-computability in physical laws — as Penrose has always claimed.

Stuart Hameroff, whose talk was in another session (but treated here for its connection to Penrose), gave a brief history of the use of anaesthetic gases of various chemical structures, but with similar effects with respect to putting people (and other organisms) out of consciousness. In the nineteenth century some of these gases were found to cause euphoria at low concentrations, but at higher concentrations rendered animals and humans unconscious and unresponsive. In fact, for each anaesthetic gas, a particular average concentration caused all kinds of animal species, from insects to humans, to become unresponsive/unconscious. Scientists also found a correlation between anaesthetic potency and lipid (oil) solubility, the so-called Meyer-Overton correlation. In the late twentieth century, when ion channels were identified as key elements in the generation of neuronal firing, their selective blocking by certain chemicals became of interest to anaesthetic research.

Anaesthetic gases appear to bind non-specifically by weak quantum forces in various parts of the human brain, but selectively preventing consciousness. The Orch-OR theory considers consciousness to derive from entangled quantum vibrations in microtubules inside brain neurons. Hameroff is involved in a project comparing different theories of consciousness, and will closely examine known neural correlates of consciousness (NCC), by e.g. studying the actions of anaesthetics and psychedelic drug molecules. The Orch-OR theory suggests that anaesthetics dampen and psychedelics promote quantum vibrations in microtubules.

The project will also explore the nature of EEG rhythms, their coherence and overall meaning, where the EEG gamma frequency (typically the '40 Hz oscillations', first discovered by Walter Freeman in the olfactory bulb of rodents and in the late 1980s were found to be correlated with visual awareness in cats) is considered by Hameroff and many others (including myself) to be the best measurable NCC. Orch-OR suggests that gamma synchrony and other EEG derives as interference beats of quantum vibrations in microtubules.

As an hypothesis, Hameroff reiterated the ancient and attractive idea that the universe, including all life forms, consists of multiscale hierarchical oscillations at several ranges. The great challenge for science would be to link the various frequencies of existence to each other to get a coherent and complete understanding of how the microscopic world of particle and microtubule vibrations relates to the mesoscopic oscillations of neurons and networks, and to the macroscopic rhythms of organisms and social interactions (Liljenström and Svedin, 2005).

A healthy and critically sound, but not negative, view on quantum mechanics and microtubules for anaesthetics and consciousness was given by anaesthesiologist **George Mashour** (University of Michigan), who reported on the first experiments testing anaesthetic interactions with classical and entangled photons. Mashour sees no compelling reason to invoke QM in today's neuroscience, but if it ever will, it would revolutionize our understanding.

Although it has been known for a long time that anaesthetic unconsciousness, as a result of certain molecules, seems to work every time and across all biological species, including plants, the mechanisms are still not known. As early as the late 1960s it was hypothesized that anaesthetics might work on microtubules, although the dominant view is that the targets are membrane proteins. In fact, the cytoskeleton and microtubules may not only serve as supporting structures in the cells, but could also be used for information processing and transmission, possibly with quantum effects.

Even though there seems to be no direct evidence for quantum effects at the (relatively) 'macroscopic' scale of microtubules, Mashour referred to recent experimental work, where entangled photons seem to be involved in photosynthesis. Photosynthesis is apparently inhibited by anaesthetics, such as ether, where chromophores in plants appear to absorb entangled photons, but the biological significance of this is still unknown. We are still lacking a model system with macroscale quantum properties at high (biological) temperatures, which has been one of the main arguments against quantum relevance for biology.

An interesting connection to the reports of photosynthesis and entangled photons was a talk on *neurophotonics* by **Felix Scholkmann** (University of Zurich). This fascinating new research area includes optical neuroimaging, cellular and tissue autoluminescence, and light effects on brain tissue and function. Already in 1977, Franz Jöbsis reported that near-infrared (NIR) light can penetrate the whole head/brain, and this technique could be used to measure cerebral blood perfusion non-invasively in humans. Later, it was shown that humans also *emit* light, in particular in the IR region, but also in the optical region, a phenomenon called *ultraweak photon emission* (UPE). The amount of light emitted (for example from a human hand) depends on the state of the subject and the time of day, but it is primarily a non-thermal emission.

A question here is whether mitochondria and perhaps also microtubules can act like electrical or optical cables in the cells. In any case, it seems that light can trigger neurotransmitter release, and thus can be used to influence brain activity and neurobiological processes, but it is uncertain if quantum physics is involved. Even if there seems to be increasing evidence for a quantum biology (see Al-Khalili and McFadden, 2014), there are still many fundamental problems involved, and Scholkmann believes that a new framework in physics will replace quantum physics, at least as a role in biology.

Perhaps a little surprisingly, **David Chalmers** also gave a talk on quantum physics and consciousness. Indeed, at TSC 2015 in Helsinki he talked about consciousness causing the collapse of the Schrödinger wave function. Now, Chalmers together with Kelvin McQueen, a young philosopher affiliated with Chapman University, had developed the idea further. Chalmers' talk this time had the cryptic title 'Zeno Goes to Copenhagen', which alluded to the old Greek philosopher Zeno's paradoxes, and the Copenhagen interpretation of quantum mechanics.

The so-called Quantum Zeno Effect (QZE) concerns a phenomenon in quantum physics where observing (measuring) a particle prevents it from decaying, as it would in the absence of observation. The Copenhagen interpretation of QM states that a measurement collapses the wave function, and, according to Wigner, this means that consciousness causes the collapse. Chalmers and McQueen argue that the Copenhagen interpretation suffers from a dilemma arising from the QZE, and they wonder whether the dilemma could be solved.

Chalmers is primarily interested in phenomenal consciousness, i.e. subjective experience, sentience, qualia, 'what it is like to perceive, feel, and think'. The *easy problems* concern how physical processes can explain behaviour and functions, while the *hard problem* is to explain subjective experience, which the physical processes seem not able to do. Chalmers brought this up as early as the first TSC conference, but so far no one has been close to solving the hard problem. The question is, of course, what kind of explanation is required and satisfactory? Is it the same for everyone, or do different people consider different answers to be adequate and sufficient? Some think it is not a problem at all, and believe consciousness — to the extent it exists — has already been explained (e.g. Dennett, 1991). Nevertheless, Chalmers listed three main optional approaches to the solution: (1) illusionism, i.e. consciousness does not exist, (2) panpsychism, i.e. consciousness is everywhere, and (3) dualism, i.e. consciousness is non-physical. Each one of these 'solutions' comes with a problem: (1) is unbelievable, (2) suffers from the combination problem, and (3) has the interaction problem. Chalmers declared that he would not attempt to solve the hard problem, and not endorse any of the views, just explore them.

At the heart of the problem is the *consciousness-collapse hypothesis,* which states that consciousness plays a causal role in the physical world by bringing about wave-function collapse (Wigner, Stapp, and others), and that a conscious observation collapses a superposed wave function onto a definite state. This is a special version of the *measurement-collapse interpretation* of QM. Alternative interpretations include the *many-worlds* interpretation (Everett), *hidden-variable* interpretation (Bohm), *spontaneous collapse* interpretation (Ghirardi-Rimini-Weber, Pearle), *space-time collapse* interpretation (Penrose), and quantum Bayesianism (Fuchs).

After a long and rather elaborate discussion on the various interpretations and their problems, and where Chalmers referred to the concept of PCC — the Physical Correlate of Consciousness (in analogy with the more commonly used acronym, NCC), he summarized his conclusions regarding consciousness- and measurement-collapses. Consciousness-collapse views need either (1) no PCC (strong dualism), or (2) a wave-function PCC. Measurement-collapse views need either (1) strong dualism, or (2) measurement as a wave-function property. So, after all, there is some small hope for a causal role for non-physical consciousness in the physical world. (Chalmers claimed to be interested in dualism, but strong dualism was too strong for him.)

While most contributions to the Physics Alp tried to link quantum physics more or less directly to consciousness, **Thomas Filk** (University of Freiburg) asked the (here) provocative question, 'What is Quantum-Like in Consciousness?'. His own response was that consciousness is not a quantum feature, and told a story about Heisenberg and Dirac on a farm in Ireland. Heisenberg says to Dirac: 'Look, those sheep have been shorn', and Dirac responds: 'Yes, at least on this side.' The point is that we should not make statements about things we don't observe, in particular in QM or consciousness research.

Filk continued with another famous example, when Einstein and Bohr discussed quantum physics and reality, whether the moon is there when we don't look. Similarly, one could ask whether in an ambiguous picture, such as the examples of a rabbit/duck or old/young woman, which of the two possible perspectives exists when we don't look. The take-home message from these examples is that the results are created by observation.

In particular, order matters, meaning that the order (or context) in which events or phenomena appear plays a role, and may give different results. In social science, this is obvious, but it has to be recognized also in the natural sciences that context, or order, is essential in observations or experiments. In questionnaires, we often 'compel' a person to assume a definite opinion. By a particular question, we (usually) don't produce a particular opinion but we produce the 'attribute' of having an opinion. Similarly in quantum theory: by particular observations we don't produce a particular result, but we produce the attribute of having a result with respect to the observable. A measurement is a process which is an interaction between an observing and an observed system, but it also changes the observing system *and* the observed system (*cf.* intervention).

Filk then referred to the *Strong Free Will Theorem*, as stated by Conway and Kochen (2009): '…if indeed we humans have free will, then elementary particles already have their own small share of this valuable commodity.' This is, of course, an argument for panpsychism.

Actually, the main point here, according to Filk, is that there is a *similarity* between quantum theory and consciousness, even if there is nothing fundamental that links them. He gave several examples of this kind of similarity, such as the extension of the 'Now', as the 'transition period' from potentialities to facts. Conscious experiences are temporally extended, where different processes have different timescales of an 'extended now' (from a few milliseconds up to seconds).

In quantum theory, events are never point-like (neither in space nor in time) but are extended. Within this duration, causal ordering is not even defined. Further similarities include 'entanglement', complementarity, and dealing with uncertainty. Filk also refers to the concept of *quantum cognition*, which Harald Atmanspacher, among others, talks about, and where certain features of cognition (not necessarily consciousness) are seen as similar to quantum effects, which may allow for quantitative predictions.

Filk concluded his talk by stating that, in physics, we often define objects (like photons or electrons) or attributes (like charge of energy) by the way we can measure them. We don't know what they are 'in reality' — we don't know anything about the reality of that which we measure/observe. For this reason, maybe we should not look for definitions of what a conscious or cognitive system is, but rather define these concepts in terms of experimental signatures.

3. The Biology Alp

The next mountain to climb is the Biology Alp, which has two peaks, the *Evolution Peak*, and the *Neurocognitive Peak*. We start by climbing the Evolution Peak, because it is on the route from the Physics Alp as the basis for consciousness, leading towards the Neurocognitive Peak, where the human brain–mind system is in focus.

3.1. Evolution Peak

An interesting talk on the origin and evolution of conscious experience was given by **Eva Jablonka** (Tel Aviv University). Together with Simona Ginsburg, she identifies *minimal consciousness* as a mental state with subjective experiencing, including smell, colour vision, pain, fatigue, or the feeling of the body. The question here is, again, why is there subjective experiencing and not merely an ability to respond to stimuli? Is subjective experiencing a trait, a process, or a mode of being? Following Aristotle, Jablonka suggests that subjective experiencing, like life, is an enmattered, actively and teleologically organized mode of being. Referring to Herbert Spencer (1890), she claims that mind can be understood only by showing how mind has evolved (see also Delbrück, 1986).

Like Spencer (and Delbrück), Jablonka suggests an evolutionary-transition approach to the study of consciousness, inspired by the study of the origin of life, which like experiencing is a goal-directed mode of being. In particular, she was inspired by the book *The Major*

Transitions in Evolution by John Maynard Smith and Eörs Szathmáry (1995), where a list of characteristics of life is presented (see also Liljenström and Århem, 2007). Very systematically, Jablonka went through the various steps in her evolutionary approach to consciousness, which like life defies definition, but may be governed by autopoietic principles.

Jablonka identifies a list of seven jointly sufficient characteristics of consciousness: (1) unity and diversity (of sensory perception through binding processes), (2) global availability (of information to various cognitive operations), (3) flexible value (valence) systems and goals, (4) temporal thickness (the present has duration), (5) plasticity, selection/exclusion, (6) intentionality (aboutness): mapping/representation of world–body and their relations (note: this definition of intentionality is different from that of Walter Freeman, where intentionality relates to purpose, see Liljenström, 2018), and (7) embodiment, agency, self (coherence and flexible stability of world and body images from a point of view).

As with the evolution of life, where a marker is considered to be *unlimited heredity*, Jablonka introduces *Unlimited Associative Learning* (UAL) as a transition marker for minimal consciousness. UAL is a specific form of associative learning, where the number of associations that can be learned and recalled within and between the modalities during ontogeny far exceeds those that actually form during a lifetime. Second-order and higher-order learning implies recursive processes of representation. Just as unlimited heredity enables open-ended evolution, so UAL allows open-ended ontogenetic adjustments, and through cumulative learning can lead to complex behaviour.

The attributes of UAL are shown to entail all the seven characteristics of minimal consciousness, and supposedly it has evolved independently in at least three taxa — the *molluscs, the arthropods, and the vertebrates* — and was probably lost in certain groups. Jablonka suggests that associative learning in general, and UAL in particular, was the adaptability driver of the Cambrian explosion, when the body plans of most animal phyla appeared. It led to antagonistic and cooperative arms races. The arthropods (some) and the vertebrates (most) were probably the first sentient animals, Jablonka speculated.

The evolutionary approach that Jablonka is taking is indeed very attractive. However, I think the UAL and its seven characteristics, as described by Jablonka, is far more advanced than would be necessary for a minimal consciousness. For example, I am not convinced that associative memory, which should be part of cognition rather than consciousness, is a necessary trait for minimal consciousness.

In line with this, there were two talks on plant cognition/consciousness in the programme. Again, however, there is a somewhat confusing use of the words cognition and consciousness, which should be treated as separate phenomena/processes (see Liljenström and Århem, 2007). For example, the first talk in the session on 'Plant Cognition' by **Paco Calvo** (University of Murcia) was on *plant sentience*. Calvo argued convincingly that plants think and feel, and cited Wilhelm Wundt, the father of experimental psychology: 'The beginnings of mental life date from the beginnings of life' and 'Where there is life, there is mind'. Along with Wundt (and Delbrück), Calvo believes that awareness/experience is a fundamental property of cellular life, and all forms of consciousness originate from prokaryotes.

The reasons why plants have been left out in the discussion on consciousness, according to Calvo, are because they have no locomotion and no flexible cell walls, which animals have. Yet, plants adapt to a large number of stimulations, they transmit information and send long-range signals. Another example is their ability to react to and move towards light. Calvo pointed out that there are many similarities and parallels between plants and animals with a nervous system. For example, the vascular systems of plants provide an information processing network, which resembles brain-like neural networks.

The most fascinating part of Calvo's presentation was a video showing a climbing plant vine, searching for support in a pole-targeted behaviour. Playing the video at a much higher speed than real time, it showed how the plant swirls around its growing vine in circles, until it touches a pole, and then swings backwards, like throwing a lasso, thrusting it forward to get hold of the pole, so it can climb it. There really seems to be some motoric control apparatus for guiding the movement, but the movement of plants is of course much slower than in animals. Sentience, cognition, and intelligence are about information transmission and mobility, but Calvo thinks we have a biased understanding of mobility. We have to appreciate and understand the plant form of movement, and see movement and sentience as an interspecies continuum.

Apparently, plants may have some cognitive capacities, which was the topic of the next talk in this session by **Chauncey Maher** (Dickinson College). He referred to experiments on associative learning in pea seedlings, performed and reported by Monica Gagliano, who is working in the new research field of plant cognition which is 'directed at experimentally testing the cognitive abilities of plants, including perception, learning processes, memory and consciousness'.

I believe few would say that plants have minds or are cognitive systems, but we might need to extend our notion and understanding of cognition (and mind). There certainly is no consensus on the use of these concepts, but traditionally they have been used exclusively for animals, in particular for humans.

In an attempt to broaden the view on these phenomena (cognition, mind, consciousness), is it possible to extend psychological experimental paradigms to plants? As an example of associative learning in plants, Maher mentioned experiments with phototrophism, which has to do with plants' oriented/directional response to light, and where pea plants could associate a breeze/fan to light, in a kind of Pavlovian classical conditioning experiment. Maher concluded that there is strong evidence that plants learn by association.

In the discussion that followed, Hameroff remarked that plants have microtubules, as do many organisms, which would suggest that all organisms with microtubules would be conscious. This points to the notion of panpsychism, but not all the way. There was also a curious (but maybe rhetorical) question regarding whether plants can make choices. Indeed, the ability to make choices may be ubiquitous and perhaps fundamental to sentient beings.

The next step on the evolutionary path was taken by evolutionary biologist **David Edelman** (Dartmouth College), who replaced Eörs Szathmáry in the programme, with a quite entertaining presentation. However, Edelman does not believe that plants, or any organisms without a sufficiently complex neural system, would have consciousness. In fact, he believes that primary consciousness depends on the emergence of distance vision, which developed during the Cambrian era (about 540–485 million years ago), the 'golden age of sensation and movement'.

Complex brain functions exist even in invertebrates, and it seems that similar properties underlying sophisticated functions and behaviours have emerged also in nervous systems which are radically different from those of vertebrates, as the study of e.g. octopuses has shown. Octopuses have modest nervous systems that can generate impressive behaviours, but to what degree are they also conscious? What brain structures and functions are necessary for conscious experience? Which animals should we study? Are octopuses and their visual system a good candidate?

In order to answer these questions, Edelman proposed a working definition for consciousness in general: there needs to be the stitching together — or binding — of many closely contemporaneous sensory threads into a coherent, unified scene and the persistence of that scene in memory, linking perception and memory. Conscious states would correspond to bound scenes that offer content *correlated in time*, beyond that arising from segregated sensory inputs (i.e. 'integrated information?'). Edelman concluded that such a view suggests that a large number of non-human animals could be capable of subjective experience, including octopuses, as evident from studies of anatomy, physiology, and behaviour (Edelman, Baars and Seth, 2005).

With a small step in the conference, but a giant leap in evolution, **Nicholas Humphrey** (Darwin College, Cambridge) gave a talk on the limits of sentience, where he considered consciousness at a much higher level than any of the other speakers on this Evolutionary Peak. In fact, his point of departure is the human brain–mind, and then he 'goes downwards'. Humphrey declared that he is not a panpsychist, but could consider phenomenal consciousness in non-human animals, and perhaps even in machines/AI systems, although he considers it to be primarily a biological phenomenon shaped by natural selection.

It is like something to have sensations (sentience), which are personal and not the same as perception. What can make them possible? Humphrey illustrated his view by comparing with an organist playing suitable music in a cinema (as was done in the time of silent movies). What is it like to be the organist? There are two sources of information: motor commands and reflection on the sound (s)he produces with the organ. It is a dual process, where (s)he has to monitor his/her own response, copying his/her own motor commands, 'feeling by doing'. Sensation of this kind is an active response, quite different from the reflex behaviour in an amoeba, which (supposedly) is not mentally aware. At some point in evolution, reflex responses became internalized/privatized, so that inputs and outputs influence each other in feedback loops, where strange attractors may develop, Humphrey argued.

On the question as to why evolution took this course, Humphrey speculated that it was advantageous to make an efference copy, a sensation about what is you, as well as about the environment. Consciousness imbues the self with metaphysical significance, and so changes the value we place on our own and others' lives. To conceive oneself requires a brain capable of having complex attractors, in the way (maybe only) humans have, and possibly also other mammals, but probably not molluscs like the octopus.

3.2. Neurocognitive Peak

We now come to the Neurocognitive Peak, which was introduced in an in-depth workshop on 'Critical Neuroscience', organized by **Peter beim Graben** (University of Cottbus), and intended to 'reflect and discuss the methodological and "transcendental" prerequisites of current theoretical and experimental neuroscience'. His own talk was on *contextual emergence*, which was proposed to be a non-reductive relation between different levels of description of various systems where a 'lower-level' description comprises necessary but not sufficient conditions for a 'higher-level' description. He argued that the Hodgkin-Huxley action potential dynamics could be regarded as being contextually emergent upon a higher-level Markov chain description of ion channels that is not comprised by its lower-level description as molecular dynamics. He finally related NCCs with contextual emergence, where a neural system is necessary for the emergence of a conscious state.

Another talk in this workshop was by physiologist **Hans A. Braun** (University of Marburg), who talked about *stochasticity* in neural systems. Braun had reacted against rather common deterministic statements in neuroscience, such as 'We should stop talking about freedom. Our actions are determined by physical laws'. Instead, Braun emphasized the role of stochasticity, randomness in the brain, and how biological systems can take advantage of such processes.

With experimental recordings, supplemented by computer simulations, Braun demonstrated that neural systems and functions depend on randomness, which is already introduced at the lowest level of neuronal information processing, the opening and closing of ion channels. These transitions follow physiological laws, but apparently also need to make use of randomness, which will not necessarily smear out towards higher functional levels, but can be amplified by cooperative effects of the system's nonlinearities. Braun concluded by stating that 'randomness, of course, is NOT a proof of free will, but determinism is for sure NOT a good argument against'. (I will return to the problem of free will at the end of this report.)

Someone who for a long time has worked across multiple scales of neural systems is **Olaf Sporns**, who started off in biochemistry but then moved to theoretical and computational neuroscience, with a focus on complex brain networks. In the mid-1990s, Sporns worked with Nobel laureate Gerald Edelman and Giulio Tononi in trying to quantify complexity, in particular for neural networks. Together, they developed the dynamic core hypothesis (Tononi, Sporns and Edelman, 1994), related to the global workspace hypothesis by Bernard Baars (1988). The main idea is that information integration depends on network interactions that span multiple levels of organization (structural, functional, genomic, behavioural). This is now known as the integrated information theory (IIT) of consciousness.

Here, Sporns talked about *connectomics* as a sophisticated technique which utilizes brain imaging to construct structural and functional networks with varying topology. Structural connectivity provides the basis for communication dynamics, which in turn gives functional connectivity of the brain. This technique, which has already produced thousands of connectome maps of the brain, is changing the view of human brain anatomy.

The key here is that the neural networks of the brain are partitioned into clusters, hubs. In particular, so-called 'rich clubs' (RC) — which are structural hubs that are highly distributed but densely connected among themselves — provide important information on the higher-level topology of brain networks. Such networks seem directly related to different sensory modalities (vision, audition, etc.) and might play an important role for consciousness. RCs are found in many animal species, also in nematodes, and seem to be a universal feature. Also the 'resting state' of the brain, which is an unconstrained state when there are no tasks, is highly reproducible brain activity, and seems to be of RC type (Bullmore and Sporns, 2012).

Information flow in the brain is not yet understood, but functional segregation and integration are helpful tools to map network interaction across different spatial and temporal scales. Further, network analysis and computational modelling can be applied to link structure, dynamics, and function of such networks.

While Sporns and many others focus on the cognitive forms of consciousness, **Mark Solms** (University of Cape Town) set out to focus on consciousness *itself*, as the hard problem. Solms believes the roots are to be found in brainstem processes, which may modulate forebrain processes. In his talk, he raised and discussed five points: (1) the functionalist problem of consciousness, with the main question 'Why is there something it is like to *be* an organism?', which Chalmers answers with a property dualism that is difficult to accept for Solms (and many others); (2) consciousness is *not* a *cognitive* function, in fact Solms argued that 95% of our everyday goal-directed cognitive activities are unconscious; (3) consciousness is an *affective* function, the content of consciousness is generated in the cortex, but is regulated by the brainstem (a tiny lesion in the reticular formation can shut down consciousness, and children without cerebral cortex can still have feelings and maintain consciousness — Merker, 2007); (4) there is 'feeling homeostasis' for voluntary action and choice, and for the sense of here and now; (5) the functional mechanism of consciousness has to do with *free energy minimization* (Solms and Friston, 2018).

In addition to finding out what brain structures are essential for consciousness, it is also helpful to explore the effects of various drugs (and other kinds of external stimulations). There were several talks on how different types of chemical compounds can affect consciousness, not only to knock it out, as for anaesthetics (which was discussed earlier). The following talks reported here include effects of placebos and psychedelics.

Kathryn Hall (Harvard Medical School) gave an historic perspective on placebo, which previously was seen as an inert intervention, a substance or other treatment designed to have no therapeutic value, but this view has expanded to what is around the patient — also including the patient himself. It was fine to use placebo in treatments until WWII, and Hall gave early examples of mesmerism and hypnotism from the eighteenth and nineteenth centuries. Eventually, drugs were developed where the physiological effects were unknown, and could well have been placebo. It turned out that our ability to have placebo responses is tremendous.

Around 1955 there was a need to control drugs, and the use of placebo was seen as unethical, as a way to deceive the patient. Two decades later, in the 1970–80s, placebo again became of interest, also since it was recognized that it might have physiological responses, perhaps working through neurotransmitters. Placebo was not regarded just as imagination, but as a biological effect. Interestingly, placebo seems to work even without 'deception'. It is not necessary to believe in order for placebo to have effect. Hall gave examples from twelve trials that show this — so-called open-label placebo (OLP) — although not all patients respond. Much more research on placebo effects is certainly needed, also for the understanding of consciousness, as it can definitely be viewed as an example of *mind over matter*.

Placebo drugs may seem rather harmless, but some drugs — in particular psychoactive substances, or psychedelics — could induce more dramatic effects on our minds. Psychiatrist **Katrin Preller**

(University of Zurich) primarily discussed two substances: psilocybin (which exists in so-called magic mushrooms) and LSD. Both substances induce similar altered states of consciousness, but they have different structures, targeting serotonin and dopamine receptors. LSD was first developed in Basel in 1938, for the treatment of psychiatric disorders, but mainly due to its use as a narcotic, with negative psychic and social effects, there was a low interest in research and clinical use in the 1970s and 1980s. However, since the early 1990s there has been a new interest in the substance. While LSD is not considered addictive, it is definitely an hallucinogen with users experiencing brighter colours and the visual scene may be blurry or moving. There may also be an alteration in self-perception, and people report insightfulness, a state of unity, or bliss.

Altered states of consciousness induced by psychedelics may demonstrate interesting effects that otherwise are difficult to study. It can be considered a tool to investigate phenomena with clinical pharmacological treatments that may resemble effects reported in spiritual experiences. Brain-imaging data of subjects under treatment of psychedelics may reveal the functional connectivity in affected brain areas. It appears that sensory areas get highly co-activated, while there is a dis-integration of putting information together in association areas.

The final talk in the Biology Alp was given by psychologist **Olivia Carter** (University of Melbourne) with a review of previous work she had done together with Franz Vollenweider at the University of Zurich, but more recently also with philosopher Tim Bayne at Monash University. Carter wants to understand the neurobiological factors that support and influence consciousness with the help of experiences under the influence of psychedelics. But what can psychedelic research inform consciousness science, Carter asked? In what way can consciousness change in response to psychedelics, which often are said to lead to a 'higher' consciousness?

Some of the reported experiences include elementary visual alterations, audio-visual synaesthesia, vivid imagery, changed meaning of percepts, but also disembodiment, impaired control and cognition, as well as anxiety. On the positive side, some report insightfulness, religious experience, experience of unity, and blissful states. Carter lists primarily four different aspects, which are of special interest for consciousness research: (1) perception may be enhanced, e.g. sensory inhibition and gating is reduced; (2) cognition is affected, e.g. divided and selective attention is impaired, as well as cognitive control and mental manipulation, while working memory and long-term memory recall seems unaffected; (3) experience of unity — in space, time, and self — a reduction in boundary (conceptual, spatio-temporal), and conflicts and contradictions seem to dissolve; (4) different levels of consciousness should be a fruitful direction for consciousness science (see e.g. Bayne *et al*., 2016; Liljenström and Århem, 2007).

Based on her studies, Carter argued against a unidimensional view of consciousness (trying to find a single measure for consciousness), which she thinks is too simplistic. On the other hand, it is not easy to see a functional or evolutionary advantage of consciousness. Psychedelic research, which could be regarded as complementary to meditative research of altered states of consciousness, can teach us about the multidimensional nature of consciousness (Bayne and Carter, 2018).

4. The Metaphysics Alp

We have now reached the final, Metaphysics Alp, where I have also included talks with a more religious focus. Paavo Pylkkänen moderated the plenary session 'Metaphysics of Consciousness' (there were also three concurrent sessions under that heading) and the first talk there was given by philosopher **Martine Nida-Rümelin** (University of Fribourg). She argued that self-awareness provides access to our own metaphysical nature, as well as to our understanding of what it is to be identical to others.

The next speaker was **William Seager** (University of Toronto), who talked about consciousness, as many in this conference, in the meaning 'what is it like to be…'. He asked (rhetorically) why there is a problem of consciousness, why does it seem so strange in a standard physicalist view of the world that some people even deny its existence? One possibility, he suggested, is that it could be an illusion, but he had philosophical arguments against that. The main problem in today's worldview, Seager stated, originates in the mechanistic view that was formed already in the seventeenth century, where the material world is 'intrinsically passive' and entirely non-conscious. Matter, which is stuff that is capable of motion and taking up volume, is what counts, and that view still governs our intuition about the world. There is no place or need for consciousness in such a worldview. Indeed, it is not possible to explain in material terms, and hence it is rather explained away.

One way to get around the problem of matter and mind is to consider *presence* as fundamental, and then try to regard both objects (matter) and subjects (mind) as nexuses of presence. This view, Seager suggested, would be something like William James's *neutral monism*, and presence would then take the role of his 'pure existence'. The overall system of presence will generate or encompass experiencing subjects to which not everything will seem to be present. According to Seager, everything that is, is present (which to me sounds very much like 'existence'). Anyway, the issue of *agents* becomes interesting here. Human agents should simply regard the world of objects and properties as the arena of action. Though not ontologically fundamental, once differentiated into subject and object it is explicable and predictable in its own terms by science. However, this divorces science from its role of revealing reality, and replaces it with the role of intra-world explanation and prediction.

Seager concluded by recognizing that not all subsets of presence constitute subjects, so universal presence is not the same as universal minds. However, his view is still a kind of *panpsychism*, but the world is not made of micro-minds — neither subjects nor objects are fundamental. (In general, the problem with panpsychism is to understand how many small consciousnesses, say of single cells — or even atoms — can combine to *one* consciousness for an organism.)

A somewhat related talk, also addressing the fundamental aspect of consciousness in the world, which appears to be divided into 'mind' and 'matter' — and related to panpsychism — was given by the conference organizer, **Harald Atmanspacher**. By reconstructing a correspondence between the physicist Wolfgang Pauli and the psychoanalyst Carl Gustav Jung, Atmanspacher could formulate their dual-aspect approach to the mind–matter problem as an alternative conjecture to interactive dualism, idealism, and physicalism.

According to Atmanspacher, there are in principle two modes of dual-aspect thinking: (1) *composition* of psychophysically neutral elements which leads to configurations that are either mental or physical, but is *reductive*, and inspired by classical *system theory* (Mach, James, Russell, Chalmers), and (2) *decomposition* of a psychophysically neutral whole which leads to partitions, one of which is that of the mental and the physical, not reductive, and inspired by *quantum holism* (Pauli/Jung, Bohm/Hiley). The main idea here is that an original whole is partitioned, differentiated, into many parts, which of course is a central idea in many philosophical and religious traditions, both in the East and West. In the Pauli-Jung conjecture, the 'whole' is the not yet divided *collective unconscious* (as described primarily by Jung, and related to his *archetypes*), which is similar to the holistic feature of quantum physics. Pauli-Jung used the concept *unus mundus*, where there are no distinctions, as also David Bohm and Basil Hiley (1995) discuss in their book, *The Undivided Universe*.

The key features of the Pauli-Jung conjecture are that (1) *unus mundus* can be seen as one basic psychophysical neutral domain, without distinctions such as mind–matter, subject–object, self–world, (2) mind and matter emerge as epistemic domains (dual aspects) due to symmetry breakdown of the holistic *unus mundus*, (3) psychophysical correlations, PPC (e.g. *synchronicities*), reflect lost holism of the *unus mundus* (inspired by quantum holism), (4) PPC are typically expressed symbolically as meaningful correspondences (neither causal nor random), and (5) in dual-aspect approaches PPC are relations between the self-model and the world-model of a subject.

Synchronicity, which is one interesting phenomenon discussed here, is a kind of meaningful correspondence that can extend over time, and these corresponding events do not need to be simultaneous. It can be considered as temporal nonlocality, and is again an example of an *analogy* between quantum physics and mind/matter relation, which is central in *quantum cognition*. In the Pauli-Jung view, it is just a structural analogy, not an isomorphism between the two descriptions of the world.

Another analogy is the strong interaction between the observer and the observed. Observations (in physics) are interactions of an observing system O with an observed system S, where a weak interaction means no significant effect of O on S, whereas a strong interaction implies the effect of O on S makes a difference. In psychology, almost every action of O entails a significant effect on S. Strong interaction O–S is the rule rather than the exception. Observing a mental state implies recording a value of an observable plus changing the subject's state. Furthermore, results of successive observations are sequence-dependent and measurements are non-commutative operations. There are numerous successful investigations and applications of non-commutative structures in psychology, e.g. bistable perception, decision processes, order effects in questionnaires, learning in networks, and concept combinations.

In addition to the discussion on synchronicity, Atmanspacher also gave several empirical examples of deviations from the ordinary, with lots of reports of exceptional experiences. The Pauli-Jung conjecture allows for a systematic and empirically supported typology of exceptional experiences, and predicts non-commutative processes in psychology as a natural consequence. For more details on this, Atmanspacher referred to the talk by Wolfgang Fach the following day (see also Atmanspacher and Fach, 2019).

I was curious to learn more about the exceptional experiences that Atmanspacher talked about and therefore followed his suggestion to listen to psychologist **Wolfgang Fach** (Freiburg), who gave a talk in one of the last concurrent sessions. According to Fach, structural correlations form the basis for robust and replicable psychophysical relationships, while exceptional experiences (EE), of four different phenomenon classes (internal, external, coincidence, and dissociation), are elusive and non-reproducible deviations from this baseline induced under special conditions. Statistical analyses of 2,500 EE reports collected at the Institute for Frontier Areas of Psychology at Freiburg, Germany, indicate that EE are part of the human constitution and that their phenomenology is based on fundamental principles, which correspond to dual-aspect monism. Fach presented an elaborate figure with EE-patterns as a phenomenological continuum, where the four phenomena classes included (1) meaningful coincidences and extrasensory perception (coincidence phenomena), (2) automatism and mediumship, as well as sleep-paralysis and nightmare (dissociation phenomena), (3) internal presence and influence (internal phenomena), and (4) poltergeist and apparitions (external phenomena), with self- and world-models acting in all phenomena.

Even though Fach's presentation on exceptional experiences did not directly relate to religious experiences, they can (perhaps) be considered to belong to the same category. In fact, we have eventually come to the somewhat misty path that leads to the peak of the Metaphysics Alp, where peak experiences of various kinds could be seen as part of religious life or spirituality. There were two plenary talks in the session called 'Varieties of Religious Experience', given by **Jeffrey Kripal** (Rice University) and Nathaniel Barrett, respectively. Kripal's presentation concerned extraordinary (or exceptional) experiences, akin to those that were discussed by Fach. Actually, Kripal's talk, 'The Flip' was largely an advertisement for his book (Kripal, 2019).

Kripal stated that his approach is about proto-religion, that consciousness is a fundamental feature of Cosmos. He set off by reading a letter by someone called *John*, about his 'flip', which seemed to be a precognitive dream about a car accident one night that turned out to happen the next night. This was taken as an example of something supernatural, or paranormal. There are many such stories of mystical, paranormal, extraordinary experiences collected in Kripal's book, where he meant that people believe in such things because they really exist, i.e. are experienced. We should look for *meaning/purpose* instead of mechanisms.

As a contrast to Kripal's extraordinary experiences, **Nathaniel Barrett** stated from the outset that he is more interested in ordinary religious experience, which can be learnt, and would include experience of religious activities and everyday life, as religious practice. Barrett wanted to connect the science of consciousness with the science of religion, which would result in a 'technology of imagination' (a concept that remained unclear to me).

Barrett started by giving an account of Kantian theory of imagination, where imagination 'synthesizes, connects, brings together different items into a unified complex'. All images of experience (object of perception, etc.) are synthesized unities. The creative work of the imagination is to make the imagery of consciousness. In contrast, Barrett proposed a non-Kantian theory of imagination, with inspiration from pragmatism, ecological psychology, coordination dynamics, and Freeman neurodynamics (Freeman, 2000).

Imagination is for action, it is a fine-tuned control of behaviour with key traits of engagement (e.g. interaction, staying in touch with the world), enhancement (continuous variation), and enjoyment (tension, satisfaction; all experience is charged with value). In Barrett's view, religion is seen as a technology of the imagination, implying that the imaginative repertoire is an evolving set of possible imagery, constrained by habit. His thesis is that *cultivation of the imagination is the core of religiosity*. The fact that we, as humans, can use our imagination to make tools or art is a good example of the power of the *human* mind, which (supposedly) no other animal can. However, in the discussion that followed the two 'religious' talks, someone remarked that the kind of experiences discussed in the talks are not so important for religion. Instead, 'wonder is the basis of religion'.

An issue that was remarkably little discussed in this conference, but which has both philosophical and religious implications, is the problem of free will. The sense of acting, or intending to act, should be equally important for a science of consciousness as the sense of being or perceiving (Liljenström, 2011). Historically, free will has been discussed a lot in philosophical and religious contexts, and only recently in a scientific context. At TSC 2019, there was no plenary session directly related to free will, but there was one in-depth workshop on 'Free Will and Quantum Agency' (discussed at the beginning of this report), and a concurrent session on 'Agency'.

One of the talks in the 'Agency' session was on investigating neural biomarkers for volitional control (Xerxes Arsiwalla), another on how the sense of agency strengthens the sense of (bodily) ownership (Pietro Perconti), and on the role of consciousness for voluntary control applied to criminal law (Ana Bárbara Britto). Even though not explicit in their talks, these presentations seemed to presuppose the existence of free will, which is not a dominant view today. Two talks in this session directly addressed the issue of free will, one by Ken Morgi on choice multiplicity, where he presented a model of free will as a process of the conscious self having a veto for certain actions. The other was my own talk, where I summarized our neurocomputational modelling of decision making (Hassannejad Nazir and Liljenström, 2015), and demonstrated that the arguments for a causative conscious will are at least as strong as those for an illusory conscious will. I also presented the newly started international project *The Neurophilosophy of Free Will* (see www.neurophil-freewill.org), which is jointly funded by the John Templeton Foundation and the Fetzer-Franklin Fund, and which gathers 17 neuroscientists and philosophers in a consortium that will investigate the role of consciousness in decision making and actions.

This concludes the adventurous climb in the alpine landscape of consciousness science, and we will now move back to the quiet valley where we can contemplate the experiences and insights we may have gained.

4. Reflections

Although the conference was held in too hot a conference centre to digest everything, many talks were inspiring and there was also ample time for discussion and dialogue, both in the programme and outside. In addition to all the oral presentations, panel discussions, and poster sessions, the programme offered a nice intermission with a conversation between (an acted) Descartes and David Chalmers, and with a little prize ceremony where the Mind–Matter Prize for 2019 was given to Chalmers for his long-standing work on the role of consciousness in nature. On the final evening, there was a conference dinner, which I unfortunately could not attend due to travelling.

Despite all the facts and theories presented and discussed at the conference, we were not able to move much beyond a stage which still reminds me of the pre-Copernican era of physics. We don't even have any consensus on a definition of consciousness, or what would be an acceptable model/explanation of what it is to be conscious. There is certainly a need for a better taxonomy and classification of various forms of consciousness, a more elaborate language that can describe and compare different levels, states, and aspects of consciousness — and more experimental work to reveal its secrets.

So, with the mountain metaphor, could the Physics, Biology, and Metaphysics Alps described here be seen as one single massif of consciousness science, where there are clear paths between the alps, or are the valleys between too deep? My impression is that the gaps are wide and it will take still some time to connect the research in the different fields into a coherent view.

A major problem, and a challenge for a science of consciousness (as for any science), is to link processes and phenomena at different spatial and temporal scales. In particular, to connect the microscopic quantum level of atoms and molecules to the mesoscopic level of neurons and networks, and to the macroscopic(?) levels of mental phenomena (see e.g. Liljenström and Svedin, 2005).

Even though I was trained as a theoretical (bio)physicist, I'm not too excited about quantum consciousness and I still haven't been convinced that QM could play a major role in either brain or mind. Actually, I side with Atmanspacher in using quantum physics primarily as an *analogy* for consciousness or cognition. (There may of course be some deep 'truth' in QM as fundamental to consciousness, as to all matter, but it is still hidden in the clouds.)

There is in general also the problem of causality, where both bottom-up and top-down need to be consolidated in some kind of circular causality (Liljenström, 2018). It should also be recognized that there are different levels of understanding/describing phenomena, depending on which discipline or angle a phenomenon like consciousness is studied from, which may make it difficult to reach a consensus on any particular hypothesis or explanation.

While quantum physics may have been over-represented at this conference (compared to other conferences on consciousness), panpsychism and evolutionary aspects were also in focus, perhaps even more than neural aspects. Indeed, from an evolutionary perspective, it is not easy to see how or when consciousness evolved, and for what purpose (if any), which is one reason for invoking panpsychic hypotheses. Yet, many would probably expect advances in neuroscience to contribute most to our understanding of consciousness.

Despite some bright peaks in the alpine landscape of consciousness, most of the time we are still wandering around in the darkness of the deep valleys, but every now and then we might get that (deceptive?) feeling that we have reached some insight — and think we are standing on a mountain top with a gorgeous view of the consciousness landscape.

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