Models of Consciousness

A conference on formal approaches to the mind-matter relation

Mathematical Institute, University of Oxford
September 9 - 12, 2019

Sponsors and organising institutions

FEDERICO & ELVIA FAGGIN FOUNDATION

OMCAN
Oxford Mathematics of Consciousness and Applications Network

Leibniz Universität Hannover

UNIVERSITY OF OXFORD

SOCIETY FOR MIND-MATTER RESEARCH

PROGRAMME

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Welcome

Consciousness and its place in nature have collectively been one of the great mysteries of humanity and have served as the focus of philosophical and religious investigations for almost two millennia. Internationally the subject has generated sustained interest among mathematicians, physicists, and others who aim to translate the results of previous investigations into formal-mathematical models. This interest has been fuelled by the observation that many relevant questions, e.g. about the connection between fundamental physics and consciousness, are not amenable to less formal analysis. To date, much of this work has been pursued in isolation and outside of the academic mainstream. The aim of this conference is to begin to change that by fostering collaboration and the exchange of ideas between researchers interested in these ideas.

Oxford was chosen as the site of what hopefully will be the first of many such conferences due to the idyllic intellectual and aesthetic environment as well as the presence of the Oxford Mathematics of Consciousness and Applications Network (OMCAN). The origin of the modern concept of consciousness is often attributed to John Locke's Essay Concerning Human Understanding, published in 1690. Locke was, himself, a graduate of Christ Church, Oxford. Locke defined consciousness as "the perception of what passes in a man's own mind" and this definition was included in Samuel Johnson's 1755 Dictionary. Johnson, himself, had attended Pembroke College, Oxford and was the recipient of a Master of Arts from the University. So it is appropriate to be returning to this hallowed ground to discuss and debate these issues.
Welcome to Oxford!

The conference team

Organisers*

Dr Johannes Kleiner
Institute for Theoretical Physics
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Germany

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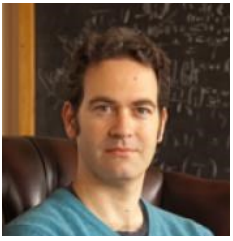
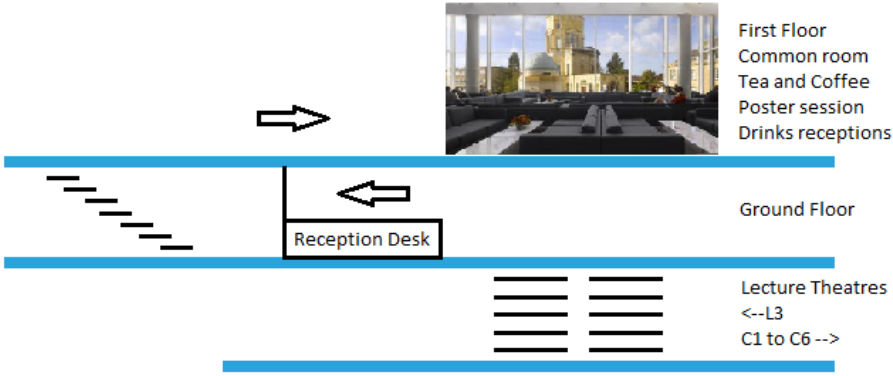
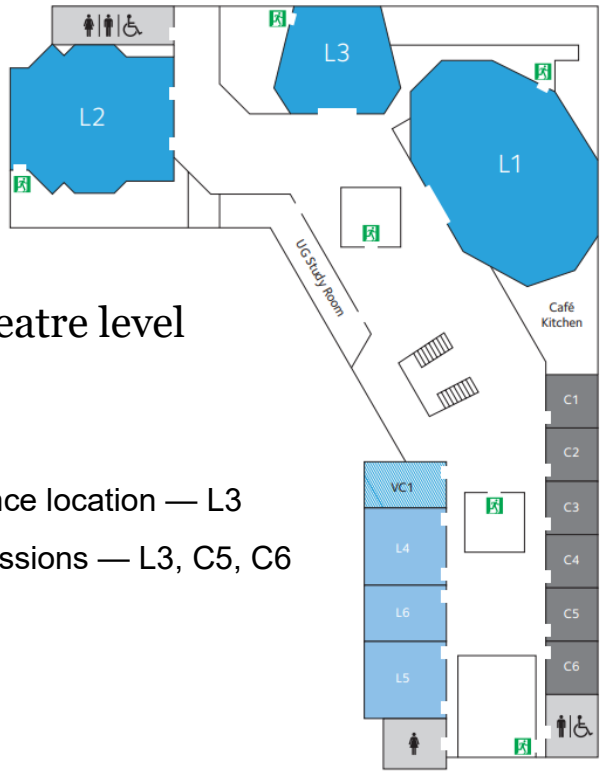


Prof. Yakov Kremnitzer
Oxford Mathematics of Consciousness and Applications Network (OMCAN)
Mathematical Institute
University of Oxford
UK

*The advisory board gratefully acknowledges the work and effort of all the organisers and gives particular thanks to Dr Kleiner who lead the work.

Building plan





Lecture theatre level & Café

Main conference location — L3

Discussion sessions — L3, C5, C6

Conference dinner

Somerville College (19:00 Wednesday 11th Sep)

For those joining the conference dinner on Wednesday 11th September, the dinner is being held at Somerville College Oxford, just a short walk from the Mathematical Institute. The College is entered through the Lodge House (pictured right) on the Woodstock Road. See the map on the next page for the location.

Coffee, tea, lunch and drinks

The Common room

Coffee and tea breaks will be held in the Common room on the first floor of the Mathematical Institute. Conference participants may need to show their conference badges to be allowed through the glass doors at the ground floor reception desk. The poster session and drinks receptions will also be held in the Common room.

Lunch

Conference participants are welcome to have lunch in the Mathematical Institute Café located on the same level as the lecture theatres. Alternatively, there are many local pubs and restaurants within a few minutes walk of the Mathematical Institute along Walton Street, and Little Clarendon Street; see the next page.

Area map

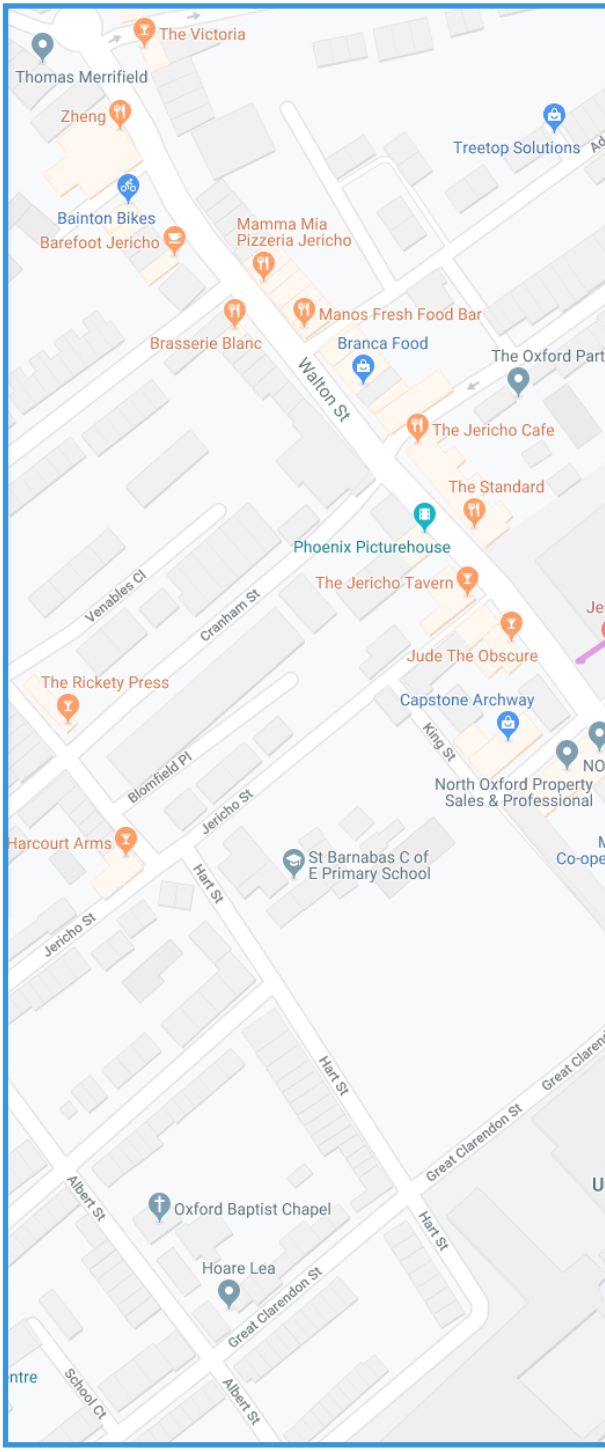
Eating and drink out

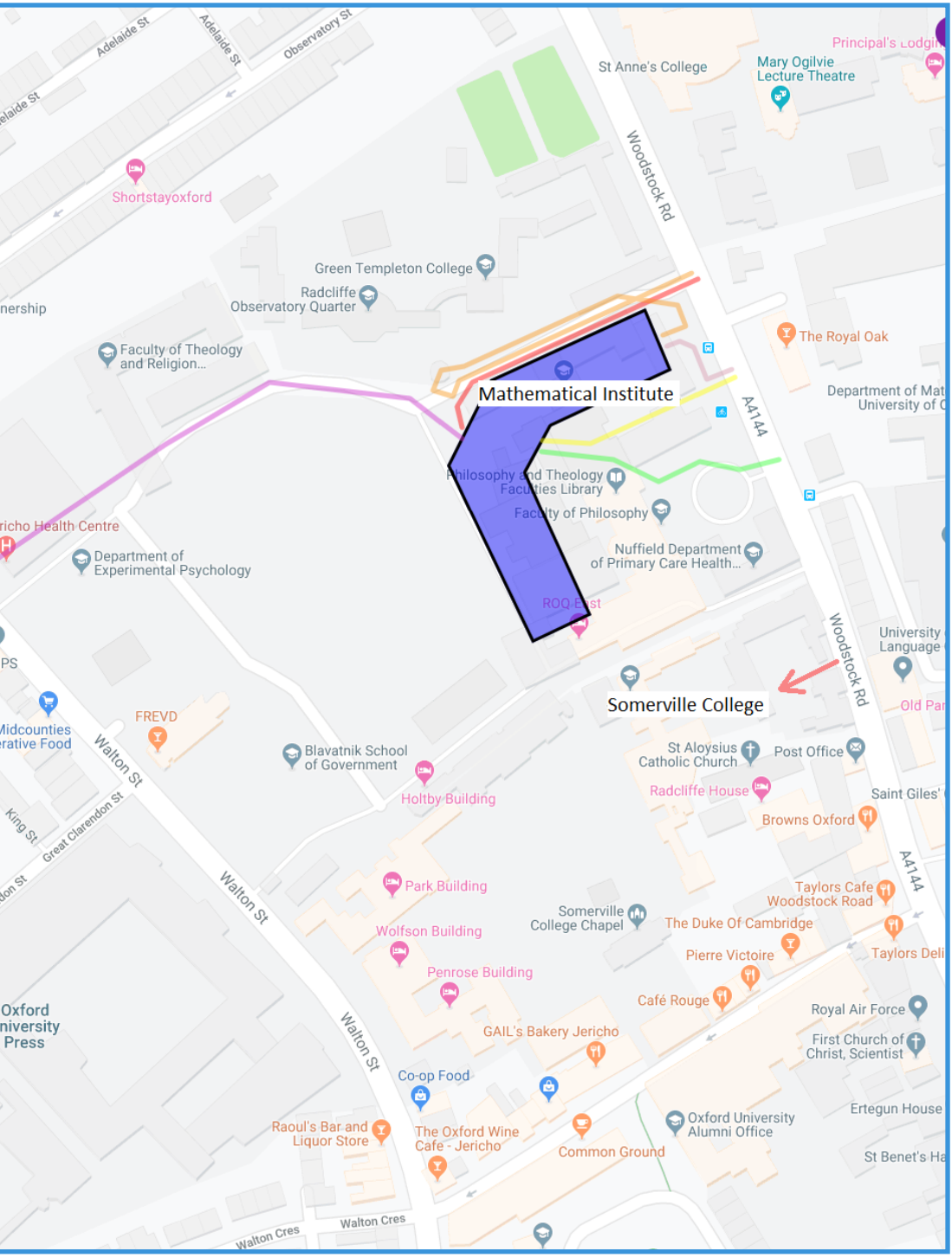
Restaurants:

- Café in the Mathematical Institute
- The Pierre Victoire (French Cuisine)
- Will's Deli
- Branca (deli and restaurant)
- Opera Cafe
- Al-Shami (Lebanese/Syrian)
- Cafe Rouge

Pubs (typically good food too):

- The Royal Oak
- The Gardener's Arms on Plantation Road (good and exclusively vegetarian menu)
- Eagle and Child (for Toklien and C.S.Lewis fans)
- The Rose and Crown
- The Victoria
- The White Rabbit (they have vegan pizza)
- The Rickety Press
- The Jerico Tavern
- The Harcourt Arms
- The King's Arms




Mathematical Institute
Somerville College
Adelaide St
Observatory St
Woodstock Rd
St Anne's College
Mary Ogilvie Lecture Theatre
Shortstayoxford
Green Templeton College
Radcliffe Observatory Quarter
Faculty of Theology and Religion...
The Royal Oak
A4144
Philosophy and Theology Faculties Library
Faculty of Philosophy
Department of Experimental Psychology
Nuffield Department of Primary Care Health...
ROQ East
University Language
FREVD
Blavatnik School of Government
Holtby Building
St Aloysius Catholic Church
Post Office
Radcliffe House
Browns Oxford
Walton St
Great Clarendon St
King St
Park Building
Wolfson Building
Somerville College Chapel
Penrose Building
The Duke Of Cambridge
Taylors Cafe Woodstock Road
Pierre Victoire
Café Rouge
Royal Air Force
First Church of Christ, Scientist
GAIL's Bakery Jericho
Co-op Food
Raoul's Bar and Liquor Store
The Oxford Wine Cafe - Jericho
Common Ground
Oxford University Alumni Office
Ertegun House
Walton Cres

Programme schedule

	Monday
From 8:15	Registration (outside L3)
08:45 - 09:00	Welcome (L3)
09:00 - 10:00	Invited Talk (L3) **1 William Marshall**
10:00 - 10:30	Coffee (Common room)
10:30 - 10:55	**2 Johannes Kleiner** (L3)
10:55 - 11:20	**3 Adam Barrett**
11:20 - 11:45	**4 Xerxes Arsiwalla**
11:45 - 12:45	Discussion Session 1 (L3, C5, C6)
12:45 - 14:00	Lunch
14:00 - 15:00	Invited Talk (L3) **5 Sir Roger Penrose**
15:00 - 15:25	**6 Stuart Hameroff** (L3)
15:25 - 15:50	**7 Sean Tull** (L3)
15:50 - 16:10	Coffee (Common room)
16:10 - 16:35	**8 Paul Skokowski** (L3)
16:35 - 17:00	**9 Camilo Signorelli**
17:00 - 18:00	Discussion Session 2 (L3, C5, C6)
18:00 - 19:00	Joint Poster Session with Drinks (Common room)

	Tuesday
09:00 - 10:00	Invited Talk (L3) **10 Peter Grindrod**
10:00 - 10:30	Coffee (Common room)
10:30 - 10:55	**11 Pedro Resende** (L3)
10:55 - 11:20	**12 Aaron Sloman**
11:20 - 11:45	**13 Agne Alijauskaite**
11:45 - 12:45	Discussion Session 3 (L3, C5, C6)
12:45 - 14:00	Lunch
14:00 - 15:00	Invited Talk (L3) **14 Jonathan Mason**
15:00 - 15:50	Invited Talk (L3) **15 Tim Palmer**
15:50 - 16:10	Coffee (Common room)
16:10 - 16:35	**16 Peter Lloyd** (L3)
16:35 - 17:10	**17 Ian Durham** (L3)
17:10 - 18:00	Drinks Reception with Nibbles (Common room)
18:00 - 19:00	Evening Invited Talk (L3) **18 Adrian Kent**
19:00 - 20:00	Evening Discussion 4 Sessions (L3, C5, C6)

*The poster session is being jointly held with the Higher-order Interaction Networks conference.

	Wednesday
09:00 - 10:00	Invited Talk (L3) **19 Yakov Kremnitzer**
10:00 - 10:30	Coffee (Common room)
10:30 - 10:55	**20 Michael Silberstein** (L3)
10:55 - 11:20	**21 Ramón Guevara Erra**
11:20 - 11:45	**22 Anita Mehta**
11:45 - 12:45	Discussion Session 5 (L3, C5, C6)
12:45 - 14:00	Lunch
14:00 - 14:50	Invited Talk (L3) **23 Mauro D'Ariano**
14:50 - 15:15	**24 Paul Baird** (L3)
15:15 - 15:40	**25 Pierre Baudot**
15:40 - 16:10	Coffee (Common room)
16:10 - 16:35	**26 Shanna Dobson** (L3)
16:35 - 17:00	**27 Quanlong Wang**
17:00 - 18:00	Discussion Session 6 (L3, C5, C6)
18:00 - 19:00	
19:00 - late	Drinks Reception and Conference Dinner (Somerville College)

	Thursday
09:00 - 10:00	Invited Talk (L3) **28 Chetan Prakash**
10:00 - 10:30	Coffee (Common room)
10:30 - 10:55	**29 Aïda Elamrani** (L3)
10:55 - 11:20	**30 Diana Stanciu**
11:20 - 11:45	**31 Marc Ebner**
11:45 - 12:45	Discussion Session 7 (L3, C5, C6)
12:45 - 14:00	Lunch
14:00 - 14:25	**32 Andrej Bicanski** (L3)
14:25 - 14:50	**33 Gustav Bernroider**
14:50 - 15:15	**34 Inês Hipólito**
15:15 - 15:40	**35 Pedro Mediano**
15:40 - 16:10	Coffee (Common room)
16:10 - 16:35	**36 Jeff Yoshimi** (L3)
16:35 - 17:00	**37 John Barnden**
17:00 - 18:00	Closing Discussion Session 8 (Plenary L3)

Talk titles and abstracts

1 William Marshall (Invited)

Department of Mathematics and Statistics, Brock University

Integrated Information Theory: From Phenomenal to Physical

The dominant approach in consciousness science is to identify the neural correlates of consciousness – neural activity which correlates with specific experiences. However, many have argued that the subjective nature of experience makes it difficult (if not impossible) to distill consciousness from neural activity (the so-called "hard problem"). Integrated information theory takes a different approach, starting from consciousness itself to identify its essential properties, and then postulating what sort of physical substrate could support it.

In this talk, I briefly review the phenomenal approach of IIT and the mathematical framework that follows from it. I will then outline some of the explanations, predictions, and inferences made by the theory. Finally, I will discuss new developments to the theory and how they can be used to explain certain qualitative aspects of experience.

2 Johannes Kleiner

Institute for Theoretical Physics, Leibniz University of Hannover

On the Mathematical Basis of Models of Consciousness

The goal of this talk is to discuss the mathematical basis of models of consciousness, most notably the question of which mathematical structure one is to use to describe experience in any formal theory. This question is inextricably linked with the conceptual basis of models of consciousness.

After briefly reviewing the various choices made in existing models, I explain how a systematic answer to this question can be constructed based on a further development of the concepts introduced by Thomas Nagel and David Chalmers. If time permits, I will outline how this leads to a full mathematical framework for models of consciousness.

3 Adam Barrett

Sackler Centre for Consciousness Science, University of Sussex, UK

Integrated information theory: a perspective on `weak' and `strong' versions

Integrated Information Theory (IIT) has gained a lot of attention for potentially explaining, fundamentally, what is the physical substrate of consciousness. The foundational concepts behind IIT were extremely innovative, and it has been very exciting to see certain predictions being upheld in experiments. However, many problems have been uncovered with the mathematical formulae that IIT proposes for measuring consciousness exactly. This has led to fragmentation amongst consciousness researchers, between those who accept IIT, and those

who reject IIT.
In this talk, I make the case for a `weak' form of IIT as a pillar of a future theory of consciousness, and summarise some of the problems with `strong' IIT. Weak IIT maintains that neural correlates of consciousness must reflect two key aspects of phenomenology. First, that each conscious moment is extremely informative (it is one of a vast repertoire of possible experiences). Second, that each conscious experience is integrated (it is experienced as a coherent whole). I review some of the empirical evidence for this, in the form of greater diversity and connectivity in observed neural dynamics from conscious versus unconscious humans. I then discuss how the Phi measure of integrated information is not well-defined, and not unique given the axioms of IIT, and hence that the current version of strong IIT should be rejected. I conclude with some discussion on possible ways forward.

4 Xerxes Arsiwalla

Institute for Bioengineering of Catalonia Barcelona, Spain

Computing Meaning from Conceptual Structures in Integrated Information Theory

Theories of consciousness such as Integrated Information Theory (IIT) and its various approximations are grounded on intrinsic information and causal dynamics. However, what seems to be missing or at least is not explicitly addressed in this framework is the role of meaning. One could argue that conscious experience not only generates information, but also meaning. We postulate that meaning associated to experience is intrinsically generated, is compositional, specific and integrated. How can this be formalized within the context of IIT? Here we propose a framework for computing the compositional meaning of the maximally irreducible conceptual structure or Q-shape in IIT. A Q-shape is a set of concepts and their relations. To compute the meaning of a Q-shape we apply the category theoretic formulation of Distributional Semantics, used in natural language processing. This assigns to every concept in the Q-shape, a distributional meaning and a grammatical type. By consistency, concepts with very high phi (core concepts) will be the most pertinent for the experience at that specific instance. The distributional meaning of each core concept depends on its relations to all other concepts in the Q-shape and can be computed using a vector space spanned by a basis of concepts as is done in Distributional Semantics. The grammatical types associated to core concepts are constrained by their relations to other core concepts. Furthermore, a pre-group algebra imposes ordering of grammatical types. We then show how the sub-network of core concepts in the Q-shape can be identified with a category theoretic process diagram. The compositional meaning of this process diagram is computed within a monoidal category and yields the meaning associated to the experience. We demonstrate this computation with a simple toy model. Finally, we comment on how meaning imposes phenomenologically relevant constraints to any information-based theory of consciousness.

5 Sir Roger Penrose (Invited)

Mathematical Institute, University of Oxford

AI, Consciousness, Computation, and Physical Law

A common scientific view is that the actions of a human brain could, in principle, be simulated by appropriate computation, and even that it may not be too far into the future before computers become so powerful that they will be able to exceed the mental capabilities of any human being. However, by using examples from chess and mathematics, I argue, that the quality of conscious understanding is something essentially distinct from computation. Nevertheless, I maintain that the action of a conscious brain is the product of physical laws, whence consciousness itself must result from physical processes of some kind. Yet physical actions, over a huge range, can be simulated very precisely by computational techniques, as is exemplified by the LIGO gravitational wave detectors confirming precise calculations, within Einstein's general relativity theory, of signals from black-hole encounters in distant galaxies.

Despite this, I argue that there is a profound gap in our understanding of how Einstein's theory affects quantum systems, and that there is reason to believe that the events termed "collapse of the wave-function" take place objectively (gravitational OR), in a way that defies computation, yet should be observable in certain experiments. It is argued that each such event is accompanied by a moment of "proto-consciousness", and that actual consciousness is the result of vast numbers of such events, orchestrated in an appropriate way so as to provide an actual conscious experience (Orch-OR).

6 Stuart Hameroff (Invited)

Center for Consciousness Studies, University of Arizona, Tucson, Arizona

Anesthetic action on quantum terahertz oscillations in microtubules supports the Orch OR theory of consciousness

The Penrose-Hameroff 'Orchestrated objective reduction' ('Orch OR') theory suggests consciousness arises from 'orchestrated' quantum superpositioned oscillations in microtubules inside brain neurons. These evolve to reach threshold for Penrose 'objective reduction' ('OR') by E=h/t (E is the gravitational self-energy of the superposition/separation, h is the Planck-Dirac constant, and t the time at which Orch OR occurs) to give moments of conscious experience. Sequences, interference and resonance of entangled moments govern neurophysiology and provide our 'stream' of consciousness. Anesthetic gases selectively block consciousness, sparing non-conscious brain activities, binding by quantum coupling with aromatic amino acid rings inside brain proteins. Genomic, proteomic and optogenetic evidence indicate the microtubule protein tubulin as the site of anesthetic action. We (Craddock et al, Scientific Reports 7,9877, 2017) modelled couplings among all 86 aromatic amino acid rings in tubulin, and found a spectrum of terahertz ('THz') quantum oscillations including a common mode peak at 613 THz. Simulated presence of 8 different anesthetics each abolished the peak, and dampened the spectrum proportional

to anesthetic potency. Non-anesthetic gases which bind in the same regions, but do not cause anesthesia, did not abolish or dampen the THz activity. Orch OR is better supported experimentally than any other theory of consciousness.

7 Sean Tull

Department of Computer Science, University of Oxford

Generalised integrated information theories

Integrated Information Theory (IIT), developed by Giulio Tononi and collaborators, has emerged as one of the leading scientific theories of consciousness. At the heart of IIT is an algorithm which, based on the level of integration of the internal causal relationships of a physical system in a given state, claims to determine the intensity and quality of its conscious experience.
However, IIT is known to possess several technical problems, and is only applicable to simple classical physical systems. To be treated as fundamental, it should ideally be extended to more general physical theories.
In this work, we investigate the formal structure of IIT, and define a notion of generalised integrated information theory in order to address these problems. Formally such a theory specifies a mapping from a given theory of physics to one of conscious experience, each satisfying minimal conditions needed for the IIT algorithm.
In particular we show how a generalisation of IIT may be constructed from any suitable physical process theory, as described mathematically by a symmetric monoidal category. Specialising to classical processes yields IIT as usually defined, while restricting to quantum processes yields the recently proposed Quantum IIT of Zanardi et al. as a special case.

8 Paul Skokowski

Symbolic Systems and Philosophy, Stanford University;
St Edmund Hall, University of Oxford

Causal constraints on models of consciousness

Conscious experience is a phenomenon that each of us knows intimately well. The subjective characters of our sensations are immediately apparent to us. These subjective characters are qualia. Integrated Information Theory (Oizumi, Albantakis and Tononi 2014) is a model of consciousness which proposes that qualia are solipsistic, self-generated, self-referential, and holistic. We compare this view with causal constraints which apply in the natural world, and which shape the intentional properties of the experiences of biological creatures like us. A theory of physical detection is proposed to account for the contents of conscious states, grounding qualia in a way that satisfies causal constraints in the natural world.

9 Camilo Signorelli

Department of Computer Science, University of Oxford

Consciousness interaction, from experiments to a multi-layer model

Empirical evidence regarding neural studies of consciousness and conscious

perception is mainly unknown in fields such as physics and mathematics, or sometimes even misunderstood by many scientists inside the own field of consciousness research. A critical survey of these experiments reveals different aspects and dynamical features among distinct processes related to the conscious phenomenon. These features and distinctions need to be incorporated in any attempt of modelling consciousness and the study of mathematical structures of consciousness. Therefore, part of that evidence is first reviewed to later generate a preliminary multi-layer model called Consciousness interaction, suitable for further mathematical generalization. In this "prototype" of theory, biological and cellular principles together with mathematical structures are fundamental ingredients and important complement for current physical descriptions such as dynamical systems, emergent, and sub-emergent properties. One advantage of the mentioned approach is the potential of reducing the apparent number of theories of consciousness to a few models, without the need for a single experiment. Moreover, new insights and empirical predictions are expected after this theoretical exercise, eventually producing a list of few experimental tests to verify or falsify current and future models of consciousness.

10 Peter Grindrod (Invited) - joint research with Christopher Lester

Mathematical Institute, University of Oxford

Large scale simulations of information processing within the human cortex: what "inner life" occurs?

We seek to model the human cortex with 1B to 10B neurones arranged in a directed and highly modular network (a network of networks); with the tightly coupled modules (each containing 10,000 neurones or so) representing the cortical "columns". Each neurone has an excitable and refectory dynamic and the neurone-to-neurone connections incur individual time delays. Thus the whole is a massive set of modular delay-differential equations (expensive to solve on a binary computer, but easily implemented within 1.5kg of neural wet-ware). Our early work has shown why evolution has resulted in such a design to ensure optimal use of the limited space and energy available. Indeed we can show that if the time delays were all integers rather than reals then much of the potential behaviour (dynamical degrees of freedom) would be lost.

Simulating a 1B neurone directed graph produces its own big data challenge. We focus on the inner life of these complex dynamical system, and show that the dynamical responses to external stimuli result in distinct, latent (internal), dynamic "states" or modes. These inner subjective and private states govern the immediate dynamical responses to further incoming stimuli. Hence they are candidates for internal "feelings". So, what is it like to be a human? A human brain must also possess such inertial dynamical states, and a human brain can experience being within them: they are natural and necessary byproducts of the system's architecture and dynamics, and they suggest that the "hard problem of consciousness" is mainly explicable, and can be anticipated, in terms of network science and dynamical systems theory.

The numerical simulation at such large scales requires a special computing platform, such as SpiNNaker (at the University of Manchester). We will set out

the methodology to be deployed in (i) defining such complex systems; (ii) in simulating the spiking behaviour being passed around when such a system is subject to various stimuli; and (iii) the post processing - reverse engineering - of the whole system performance, to demonstrate that internal states/modes exist. We cannot reverse engineer a real human brain at the neurone-to-neurone level, but we can do so for such ambitious simulations.

11 Pedro Resende

Técnico Lisboa

Sketches of a mathematical theory of qualia

I present a mathematical definition of qualia from which a toy model of consciousness is derived, partly as an attempt to provide a mathematical formulation of the theory of qualia and concepts put forward by C.I. Lewis in 1929. This formulation is guided by the identification of basic principles that convey abstract aspects of the behavior of physical devices that "detect" qualia, such as brains of animals seem to do. The ensuing notion of space of qualia consists of a topological space Q equipped with additional algebraic structure that yields a notion of subjective time and makes Q a so-called stably Gelfand quantale. This leads to interesting conceptual consequences. For instance, "stable observers" emerge naturally and relate closely to the perception of space, which here, contrary to time, is not a primitive notion; and logical versions of quantum superposition and complementarity are obtained. Indeed a mathematical relation exists to quantum theory via operator algebras, due to which a space of qualia can also be regarded as an algebraic and topological model of quantum measurements.

12 Aaron Sloman

School of Computer Science, University of Birmingham, UK

Why current AI and neuroscience fail to replicate or explain ancient forms of spatial reasoning and mathematical consciousness?

Most recent discussions of consciousness focus on a tiny subset of loosely characterized examples of human consciousness, ignoring evolutionary origins and transitions, the diversity of human and non-human phenomena, the variety of functions of consciousness, including consciousness of: possibilities for change, constraints on those possibilities, and implications of the possibilities and constraints -- together enabling extraordinary spatial competences in many species (e.g. portia spiders, squirrels, crows, apes) and, in humans, mathematical consciousness of spatial possibilities/impossibilities/necessities, discussed by Immanuel Kant (1781). (James Gibson missed important details.) These are products of evolution's repeated discovery and use, in evolved construction-kits, of increasingly complex types of mathematical structure with constrained possibilities, used to specify new species with increasingly complex needs and behaviours, using lower-level impossibilities (constraints) to support higher level possibilities and necessities, employing new biological mechanisms that require more sophisticated information-based control. Such transitions produce new layers of control requirements: including acquisition

and use of nutrients and other resources, reproductive processes, physical and informational development in individual organisms, and recognition and use of possibilities for action and their consequences by individuals, using layered mixtures of possibilities and constraints in the environment, over varying spatial and temporal scales (e.g. sand-castles to cranes and cathedrals). I'll try to show how all this relates to aspects of mathematical consciousness noticed by Kant, essential for creative science and engineering as well as everyday actions, and also involved in spatial cognition used in ancient mathematical discoveries. In contrast, mechanisms using statistical evidence to derive probabilities cannot explain these achievements, and modern logic (unavailable to ancient mathematicians, and non-human species) lacks powerful heuristic features of spatial mathematical reasoning. New models of computation may be required, e.g. sub-neural chemistry-based computation with its mixture of discreteness and continuity (see recent work by Seth Grant).

13 Agne Alijauskaite

Vilnius University

Is conscious artificial intelligence possible?

Recently one of the most discussed questions is if it is possible to create conscious artificial intelligence. Since there are some recently published writings advocating for, for example, an affective computational model for machine consciousness, there is a pressing need to rethink the possibility of conscious AI.

My aim is to revise two crucial problems when discussing AI consciousness: first, its relation to (changing) environment; and second, the defence of a computational model against non-algorithmic approaches. These two problems are inevitably interrelated. If we agree that meaning (semantics) would be built upon the basis of the robot's causal transactions with the real world, the relation of consciousness to the environment becomes of crucial importance. Also, this defines the computability of AI consciousness because it requires a limited sequence of changes in the environment.

I will argue that the argument against strong AI is valid when grounded on quantum mechanical conscious acts which are not algorithmic. For this, I will turn to Penrose's theory as well as to Pearl's argument on environmental conditions. By showing the importance of the latter, I will claim that recent models of machine consciousness are too optimistic.

14 Jonathan Mason (Invited)

Mathematical Institute, University of Oxford

Expected Float Entropy Minimisation: A Relationship Content Theory of Consciousness

Over recent decades several complementary mathematical theories of consciousness have been put forward including Karl Friston's Free Energy Principle and Giulio Tononi's Integrated Information Theory. In contrast to these, in this talk I present the theory of Expected Float Entropy minimisation (EFE minimisation) which is an attempt to explain how the brain defines the

content of consciousness up to relationship isomorphism and has been around since 2012. EFE involves a version of conditional Shannon Entropy parameterised by relationships. For systems with bias due to learning, such as various cortical regions, certain choices for the relationship parameters are isolated since giving much lower EFE values than others and, hence, the system defines relationships. It is proposed that, in the context of all these relationships, a brain state acquires meaning in the form of the relational content of the associated experience.
In its simplest form involving only "primary relationships" EFE minimisation can also be considered as a generalisation of the initial topology (i.e. weak topology). For us the family of functions involved are the typical (probable) system states, the common domain of these functions is the set of system nodes (e.g. neurons, tuples of neurons or larger structures) and the common codomain is the set of node states. In the case of the initial topology a topology is already assumed on the common codomain and the initial topology is then the coarsest topology on the common domain for which the functions are continuous. In our case no structure is assumed on either the domain or codomain. Instead EFE minimisation simultaneously finds structures (for us weighted graphs, but topologies could in principle be used) on both the domain and codomain such that the functions are close (in some suitable sense) to being continuous whilst avoiding trivial solutions (such as the two element trivial topology) for which arbitrary improbable functions (system states) would also be continuous. Thus we find the primary relational structures that the system itself defines. In this context objects (visual and auditory) are present and EFE then extends to secondary relationships between such objects by involving correlation for example. To aid application of the theory, computationally cheaper surrogates for EFE are being developed.

15 Tim Palmer (Invited)

Department of Physics, University of Oxford

Creativity and Consciousness: A Consequence of the Brain's Extraordinary Energy Efficiency?

This talk is in two parts. In the first part, I suggest that creativity arises from a close synergy between two modes of neuronal operation (corresponding to Kahnemann's Systems 1 and 2) where in the first, the limited amount of available energy to the brain is spread across large numbers of active neuronal networks, making them susceptible to noise; and in the second, available energy is focussed on smaller subset of active networks, making them operate more deterministically. In the second part, I define consciousness in terms of an ability to perceive an object as independent of its surroundings. This implies an ability to perceive counterfactual worlds where objects are perturbed relative to their surroundings. I argue that such perception may require quantum theoretic processes to be operating in the brain, since the very formulation of quantum theory (whether in convention or unconventional interpretations) involves the primacy of states of alternate worlds - alive and dead cats and so on. I argue that the brain's reliance on such quantum processes may have arisen because they are more energy efficient than corresponding classical

processes, and give some examples to justify this. Overall, I argue that human creativity and consciousness may have arisen from the brain's evolution to become an organ of exceptional energy efficiency.

16 Peter Lloyd

School of Computing, University of Kent

Automata-theoretic approach to modelling consciousness within mental monism

There has been a recent resurgence of interest in mental monism as a theory of consciousness (Goldschmidt & Pearce 2017, Chalmers 2017, 2018), and Lloyd (2006, 2019) has defended a form of Berkeleyanism that aligns with Pearce (2014) and Schrödinger's (1958) "physical construct".

Unlike theories that take the conscious mind to supervene on the brain, mental monism faces the burden of constructing ab initio the structure and dynamics of the conscious mind without any physical substrate to fall back on. Little work has been done on modelling the constituents of the mind at this fundamental level, under the tenets of mental monism. Energy, which is the driver of the physical world, has no counterpart in the mental world, which operates informatically instead. An automata-theoretic approach to modelling the conscious mind within mental monism is therefore a natural choice to explore. The model is constrained by (a) the mind's interaction with other minds including the background consciousness, an interaction that must be mapped onto quantum mechanical measurement in the physical construct; and (b) the basic features of a mind such as individuation, privacy, mental space, psychological embodiment, attention, memory. What do these constraints imply for any substrate-free automata-theoretic model of consciousness?

17 Ian Durham (Invited)

Saint Anselm College

Toward a formal model of free will

Most discussions around the nature of free will center on whether or not it exists or can exist. Lost in this argument is the fact that we at least perceive that free will exists, whether or not it actually does. This is an important distinction. If we take an operational view of perceived free will, we can construct meaningful measures for analyzing ensembles of possible choices. I present such a formal model here that is based on statistical emergence and that gives concrete, formal measures of free choices and free will.

18 Adrian Kent (Invited)

Department of Applied Mathematics and Theoretical Physics, University of Cambridge

Searching for Physical Models of the Evolution of Consciousness

The scientific consensus is that, although many important details remain to be elaborated, Darwinian evolution can be understood in principle as a consequence of known physical laws. As William James first pointed out, the

development of human consciousness, and in particular the fact that it appears to have evolutionarily advantageous features, are hard to explain within a purely materialist Darwinian theory, according to which we would function equally well in the world if we were unconscious zombies or if pleasure and pain qualia were inverted. However, it is difficult to find attractive alternatives that have any more explanatory power. In this talk I describe toy models that are intended to illuminate the space of possibilities and the difficulties.

19 Yakov Kremnitzer (Invited)

Mathematical Institute, University of Oxford

Quantum collapse models and awareness

In this talk I will explore how quantum collapse models can be a key to understanding awareness. I will explain the mathematical structure of quantum collapse models and give an example where collapse is caused by a quantum version of integrated information (this is joint with Andre Ranchin).
I will then look at the possibility of understanding awareness from collapse models and how this could be used to model consciousness as an emergent phenomenon (joint work in progress with Johannes Kleiner).

20 Michael Silberstein

Department of Philosophy, Elizabethtown College; Department of Philosophy, University of Maryland

Quantum mechanics and the consistency of conscious experience

We discuss the implications for the determinateness and intersubjective consistency of conscious experience in two gedanken experiments from quantum mechanics (QM). In particular, we discuss Wigner's friend and the delayed choice quantum eraser experiment with a twist. These are both cases (experiments) where quantum phenomena, or at least allegedly possible quantum phenomena/experiments, and the content/ecacy of conscious experience seem to bear on one another. We discuss why these two cases raise concerns for the determinateness and intersubjective consistency of conscious experience. We outline a 4D-global constraint-based approach to explanation in general and for QM in particular that resolves any such concerns without having to invoke metaphysical quietism (as with pragmatic accounts of QM), objective collapse mechanisms or subjective collapse. In short, we provide an account of QM free from any concerns associated with either the standard formalism or relative-state formalism, an account that yields a single 4D block universe with determinate and intersubjectively consistent conscious experience for all conscious agents. Essentially the mystery in both experiments is caused by a dynamical/causal view of QM, e.g., time-evolved states in Hilbert space, and as we show this mystery can be avoided by a spatiotemporal, constraint-based view of QM, e.g., path integral calculation of probability amplitudes using future boundary conditions. What will become clear is that rather than furiously seeking some way to make dubious deep connections between quantum physics and conscious experience, the kinds of 4D adynamical global constraints that are fundamental to both classical and

quantum physics and the relationship between them, also constrain conscious experience. That is, physics properly understood, already is psychology.

21 Ramón Guevara Erra

Integrative Neuroscience and Cognition Center (UMR 8002), CNRS and Université Paris Descartes, Paris, France

Statistical mechanics of consciousness: maximization of information content of neuronal networks is associated with conscious awareness

It has been argued that consciousness could be an emergent property of large neuronal networks, associated to the integration of information in the brain. However, it is not yet clear how is consciousness related to the complexity of functional brain networks. Based on a statistical mechanics approach, we sought to identify features of brain organization that are optimal for sensory processing, and that may guide the emergence of consciousness, by analyzing neurophysiological recordings in conscious and unconscious states. We find a surprisingly simple result: Normal wakeful states are characterized by the greatest number of possible configurations of interactions between brain networks, representing highest entropy values. Therefore, the information content is larger in the network associated to conscious states, suggesting that consciousness could be the result of an optimization of information processing. These findings help to guide in a more formal sense inquiry into how consciousness arises from the organization of matter.

22 Anita Mehta

Leverhulme Visiting Professor, University of Oxford

Chasing memories

Short- and long-term memories are distinguished by their forgettability. Most of what we perceive and store is lost rather quickly to noise, as new sensations replace older ones, while some memories last for as long as we live. Synaptic dynamics is key to the process of memory storage; in this talk I will discuss a few approaches we have taken to this problem, culminating in a model of synaptic networks containing both cooperative and competitive dynamics. It turns out that the competition between synapses is key to the natural emergence of long-term memory in this model, as in reality.

23 Mauro D'Ariano (Invited)

Dipartimento di Fisica, Università degli Studi di Pavia

Awareness: an operational theoretical approach

I will explore the possibility of drawing definite theoretical assertions about "awareness", including possible experimental falsification. Awareness will be regarded as a manifestation of a special kind of "information", and, as such, formalised as an operational probabilistic theory (OPT) [1]. Awareness would correspond to "the feeling of the process" experienced by the OPT-systems involved in the process.

As a kind of information "awareness" is special in being "private". Assuming

that such privacy is an in-principle one implies a number of interesting consequences. For example, according to a theorem about information privacy in OPTs [2], investigation will be restricted to OPTs that are essentially non classical, among which the most relevant instance is the quantum theory.
After presenting the OPT framework, assessing its methodological robustness in separating objective from theoretical elements, and examining postulates guaranteeing experimental control and falsifiability, I will compare postulates of relevant OPTs, and provide mathematical definitions of notions as holism, causality, complementarity, purification, and information privacy.
Finally, I will explore the hypothesis of “awareness as quantum coherence”, providing a list of motivations and consequences, and discussing the possibility of experimental tests in cognitive sciences, including the evaluation of the number of qubits involved in the awareness, the existence of complementary observables, and violations of local-realism bounds.
[1] G. M. D’Ariano, G. Chiribella, and P. Perinotti, “Quantum Theory from First Principles: An Informational Approach” (Cambridge University Press 2017)
[2] G. M. D’Ariano, P. Perinotti, A. Tosini, “Information and disturbance in operational probabilistic theories”, unpublished

24 Paul Baird

Université de Bretagne Atlantique

A model for perceptual states
I will present a mathematical model which encapsulates 3D perception from planar 2D data: to a combinatorial graph, we associate its "geometric spectrum"; eigenstates then correspond to local realizations of the graph in Euclidean 3-space as "invariant" frameworks. In this way geometry emerges from the structure, rather than being imposed upon it.
One may attempt to construct a model universe based on such structures, in which state realization enacts change; change being synonymous with time, which at an elementary level, we hypothesize, is the realization of temporal states. A coherent time should then emerge from a "survival of the fittest" principle. Conscious entities might then be considered as systems which possess "higher order universality", that is, which process potential information (rather than hard information) such as a "potential" 3D cube, to enact their own change.

25 Pierre Baudot

Median Technologies, Marseille, France.

Information cohomology and probabilistic topos for consciousness modeling: from elementary perception to machine learning
Elementary quantitative and qualitative aspects of consciousness are investigated conjointly from the biology, neuroscience, physic and mathematic point of view, by the mean of a theory written with Bennequin that derives and extends information theory within algebraic topology. Information structures, that accounts for statistical dependencies within n-body interacting systems are interpreted a la Leibniz within a monadic-panpsychic framework where

consciounsess is information and physical, and arise from collective interactions. The electrodynamic intrinsic nature of consciousness, sustained by an analogical code, is illustrated by standard neuroscience and psychophysic results. It accounts for the diversity of the learning mechanisms, including adaptive and homeostatic processes on multiple scales, and details their expression within information theory. The axiomatization and logic of cognition are rooted in measure theory expressed within a topos intrinsic probabilistic constructive logic, allowing to express the information of mathematical formula as a Gödel code. Information topology provides a synthesis of the main models of consciousness (integrated information, global neuronal workspace, free energy principle) within a formal Gestalt theory, an expression of information structures and patterns in correspondence with Galois cohomology and symmetries. We give several examples of the application of information topology to standard recognition challenges in AI-machine learning.

26 Shanna Coleman Dobson

California State University, Los Angeles

Infinity-topoi for the combination problem

We present two ideas: First, we investigate an infinitely categorical analogue of the combination problem using higher Galois theory. We replace the ontology of the unitary operator with Hayois' equivalence of locally constant sheaves in a locally (n-1) connected n-topos to representations of its fundamental pro-n-groupoid and introduce the concept of sheaves over a point. Secondly, we use the equivalence of the etale topos of a field k to the classifying topos of the absolute Galois group of k and build combinations using torsors and the etale cohomology of causal sets over p-adic fields.

27 Quanlong Wang

Department of Computer Science, University of Oxford

Modelling consciousness divisions in ZW-calculus

Natural science has a basic assumption that there exists a kind of objectivity in the world independent of any consciousness. But how could one verify such objectivity given the fact that human beings can only perceive any existence through their own consciousness? On the other hand, there is a possibility for the existence of pure consciousness which could support the appearance of all phenomena, as claimed by the Yogācāra school of Indian philosophy. Based on this philosophy, any consciousness consists of two divisions: the perceived division (nimittabhaga in Sanskrit) and the perceiving division (darsanabhaga in Sanskrit). The perceiving division can recognise the information presented by the perceived division, they interact with each other as a whole unity. It is based on these two divisions that objectivity and subjectivity are established. In this talk, we give a mathematical model for characterising the interacting processes between the perceived division and the perceiving division within the framework of ZW-calculus, which is a graphical language representing quantum processes in compact closed categories. We expect that using this

model some key interacting processes between the perceived division and the perceiving division can be characterised, which then paves the way for further research on modelling consciousness.

28 Chetan Prakash (Invited)

California State University, San Bernardino

Structure Invention by Conscious Agents

A scientific understanding of the process whereby physical entities produce consciousness has not come about, despite decades of investigation. This suggests exploring the reversal of the celebrated "hard problem of consciousness," i.e., take consciousness as fundamental and the physical world as emergent. We describe D. Hoffman's Interface Theory of Perception in which perceptual experiences do not approximate properties of an "objective" world, but reside in simplified, species-specific, user interfaces. Building on this, the Conscious Realism Thesis states that the objective world consists entirely of a social network of 'conscious agents' and their experiences, which together create the objects and properties of our common physical world.

Using evolutionary game theory, we justify interface theory by showing that perceptual strategies reporting the truth will be driven to extinction by those tuned instead to fitness. We state further theorems on fitness beating truth, by showing that perceived structures, such as symmetries, partial orders and probabilities, will likely not be possessed by a world. We define "conscious agents," suggesting that space-time is a property of the perceptual interface of human conscious agents: physical "objects" are akin to icons on that interface; physical "phenomena" are properties of apparently interacting icons.

29 Aïda Elamrani

Institut Jean Nicod, ENS

Inputs, outputs, and meta-models

The young field of consciousness science involves highly interdisciplinary research. For this reason, it is producing heterogeneous results which are hard to compare. This emerging discipline could benefit from a unifying, theory-neutral framework for analytical purposes. To this end, we must firstly identify a common ground between concurrent models. A brief scan through history reveals that consciousness has consistently revolved around the mind vs matter dichotomy. This binary split can be argued to span a sufficiently broad and flexible domain to semantically hold any contemporary scientific formulation of the consciousness problem, since most of them strive to provide a physical account of subjective experience. Accordingly, our reverse-engineered general frame is expected to map elements from mind-space to elements from matter-space, accepting a simple functional notation: Consciousness (INPUT) = OUTPUT. Although this equation might evoke Hilary Putnam's functionalism, essential differences with the meta-model are emphasized by introducing its relation to Shannon's information. Finally, alternative implementations and applications of this representation are used to illustrate and compare current accounts of consciousness.

30 Diana Stanciu

University of Bucharest; Berlin-Brandenburg Academy of Sciences and Humanities (BBAW)

An ESR model of consciousness

I will argue that epistemic structural realism (ESR) can offer a feasible theoretical framework for the study of consciousness and its associated neurophysiological phenomena. While structural realism has already been employed in physics or biology (cf. Tegmark 2007, Leng 2010, Ainsworth 2010, 2011, McArthur 2011, Pincock 2011, Woodin 2011, Landry and Rickels 2012, Bain 2013, Andreas and Zenker 2014, Schurz 2014), its application to the study of consciousness is new indeed. Out of its two variants: ontic structural realism (OSR) and ESR, I consider the latter more suitable when studying the neurophysiological bases of consciousness since the OSR drastically claims that 'there are' actually no 'objects' and that 'structure' is all 'there is', while the ESR more moderately states that all we can 'know' is the 'structure of the relations between objects' and not the objects themselves (cf. Van Fraassen 2006). Thus, while not denying the existence of 'objects' (even if they are hard to pinpoint when discussing the neurophysiological bases of consciousness), the ESR still emphasises 'relations' vs. 'objects' and the retention of structure across theory change. In other words, it emphasies the continuity across theory change through the structural or mathematical aspects of our theories (cf. Stanford 2006).

31 Marc Ebner

Ernst-Moritz-Arndt-Universität Greifswald, Germany

A communication-based model of consciousness

The seemingly hard problem of consciousness is the problem of explaining why subjective conscious experience exist. However, Qualia is nothing mysterious. Our subjective conscious experience is comparable across individuals because we are a product of evolution. It is grounded in reality and we use it to communicate with each other. Consciousness seems to be intertwined with language. Its primary role is to serve communication between individuals. We need Qualia to communicate with others. We perceive objects within our visual field relative to the orientation of our head. This information is then stored and can also be communicated to others either during perception or at a later time. The same holds for the perception of sounds or smells. According to the theory proposed here, an assembly of neurons in the brain is in charge of consciousness. The job of this assembly is simply (a) to look at what the body does, (b) to keep a record of it, and (c) to explain it to our peers.

32 Andrej Bicanski

Institute of Cognitive Neuroscience, University College London

What can spatial cognition and its deficits tell us about consciousness?

The BB-model of spatial cognition (Bicanski and Burgess 2018, eLife) constitutes the first systems-level account of spatial memory and imagery

specified at the level of experimentally characterised single neuron responses (like place cells, grid cells, and most of the remaining known spatially selective cell types). The model shows how neural representations of egocentric spatial experiences in parietal cortex interface with viewpoint-independent representations in medial temporal areas, to enable many key aspects of spatial cognition. This account shows how the above-mentioned neural responses can map onto higher cognitive function in a modular way, and predicts how these neural populations should interact across multiple brain regions to support spatial memory, scene construction, and several other aspects of spatial cognition. For example, the model shows how grid cells could update the point of view in imagery. Intriguingly, the notion of a point of view expressed in a neural representation implicitly distinguishes the neural correlates of direct sensory experiences (or their top-down reconstruction in visuo-spatial imagery), from the neural processes that do not appear to have direct experiential correlates, albeit at a purely descriptive level. This aspect of the model suggests implications for models of consciousness, and is exemplified in simulations of hemi-neglect.

33 Gustav Bernroider

University of Salzburg, Dept. of Biosciences, Austria

Neural sense relations and consciousness: a diagrammatic approach

Are there knowable criteria for subjective entities such as conscious experience? I think there are, even physical ones. I advocate the view that the basic dualism between subject and object or mind and matter can be figured by an intuitively simple version of an inside out or inversion relation between two opposing physical domains. I propose a particular topology for subject-object relations and argue that we can find a physical realisation in the brain of living organism that provides a conformal transformation between both domains. The transformation combines two physical domains related by inversion or parity symmetry or simply by mirror reflections. This view puts topological aspects behind inversion and the associated hidden symmetries in physics into the foreground.

I introduce the model along three steps: i) evidence and motivation for the role of mirror symmetries from psychobiology based on previous studies (Senso-motory invariance in animal feelings [Bernroider G, Panksepp J. (2011), Neurosci & Biobehav. Rev., 35, 2009-2016.] and mirror-writing in (my grand-) children), ii) an intuitive diagrammatic demonstrating subject-object together with cause and effect relations mapped onto an inversive plane geometry and iii) a more formal outline and extension into the algebraic topology of non-orientable surfaces, the real and complex projective plane.

The concept suggested here offers several testable predictions for the relation of ionic brain function to inversion symmetries realised by the molecular architecture of excitable membranes. For example, this aspect seems to be evidenced by enantio-selective electronic transitions during ion conduction in the brain [Bernroider G. (2017) JIN 16, 105-113]. Going beyond these technical aspects, the present view on modelling subjectivity shifts the role of canonical coordinates together with their static dimensional geometry into the

background. It favours ideas behind general covariance. A parity transformation, if purely defined at the level of Cartesian coordinates with changing signs, is discrete, the transient itself only inferential, non-physical, with no known conserved quantity associated with this transformation in the sense of Emmy Noether's theorem. However, if the same transformation is laid out continuously on the geometry of non-orientable surfaces (e.g. on a Möbius band), the transients gain some physics and offer a conserved quantity. I will discuss this conserved quantity with respect to subjectivity and consciousness.

34 Inês Hipólito

University of Wollongong

Generative models of the mind: neural connections and cognitive integration

Building on the modular architecture of mind (Fodor 1983), Modularity Networks is claimed as a theory well equipped to explain neural connectivity and reuse (Stanley et al.; 2019, Zerrili 2019). This paper takes the case of the oculomotor system to show that even if Modularity Network's tools are useful to describe brain's functional connectivity, they are limited in explaining why such connections are formed and dynamic. To show this, section 1 starts by laying down the reasons for adopting Modularity Networks as well suited for explaining neural connectivity. Section 2 introduces the oculomotor system as a dynamic integration of action and vision. Section 3 argues that however valuable in describing the functional connectivity of the oculomotor system, Modularity Networks fails to explain why such connections are formed and dynamic (dependent on activity). This failure is made evident by acknowledging a fundamental distinction in the metaphysics of inference. The nature of inference is taken differently in functional connectivity as a description of inference as opposed to effective connectivity as an explanation of inference (Friston 2011). Section 4 introduces Dynamic Causal Modelling (DCM) as a better resource to capture effective connectivity. It allows explaining how and why brain connections, as generative models of cognitive integration, are dependent on the dynamic activity within the environment. This conclusion speaks against modular arguments for encapsulation, innateness and specificity of cognitive organisation.

35 Pedro Mediano

Department of Computing, Imperial College London

Moving beyond integration and differentiation in measures of neural dynamics

In a seminal series of papers, Tononi, Sporns, and Edelman (TSE) introduced the idea that the neural dynamics underlying conscious states are characterised by a balance of integration and differentiation between system components. This idea remains prevalent in consciousness research today, influencing theoretical and experimental work.

Such work has faced a number of challenges. For example, distinct measures designed to measure such a balance behave very differently in practice,

making it hard to choose which is the "right one", and dynamics of conscious and unconscious brains defy some of the predictions of this framework. We argue that these problems arise, at least in part, from the non-specific nature of the concepts of integration and differentiation.
Here, we present a revised mathematical theory of neural complexity: we introduce a new measure, called O-information, that quantifies the balance between redundancy and synergy within a system, and is more effective than TSE's original measure at describing phenomena where large-scale correlation and short-scale independence coexist; and develop a formalism to decompose different "modes" of information dynamics, providing an exhaustive taxonomy of redundant and synergistic effects. These developments allow us to place previous measures within a common framework and explain their their similarities and differences.

36 Jeff Yoshimi

Department of Cognitive and Information Sciences, UC Merced

Cognitive Maps for Perception, Action, and Thought
I describe a simple framework for creating "maps" of unfolding conscious processes which can be used to visualize concepts from phenomenology and neuro-phenomenology. The idea is to embed neural network models of embodied creatures in virtual environments and to record the sequences of states that unfold in the state space of their networks as they explore an environment. States can be colored according to the degree to which they are predicted to occur. In this way it is possible to visualize the way an agent's knowledge of its environment takes form, stabilizes, and is intermittently updated as its environment changes. I give demonstrations of simulations along these lines, show how these ideas be extended to the cases of action, imagination, and thought, and how they can be used to illustrate existing formalizations associated with Husserlian phenomenology, predictive processing, and reinforcement learning.

37 John Barnden

School of Computer Science, University of Birmingham, UK

Consciousness, metacausation and metadynamism
I assume that [phenomenal] consciousness is a property physical processes can have, and that it involves pre-reflective auto-sensitivity (PRAS), which is related to the much-discussed pre-reflective self-consciousness [3,4]. I then argue that PRAS requires conscious processes to be directly and causally sensitive to their own inner causation as such, and not merely to their own trajectories of physical states as ordinarily understood. That causal sensitivity is therefore metacausation. Metacausation here is where instances of causation are themselves, directly and in their own right, causes or effects. Metacausation (aka higher-order causation) is rarely discussed at all, and has apparently not previously been linked to consciousness. But the proposal is yet more radical as I merely use "causation" to mean microphysical dynamism. I assume (anti-Humeanly) that the universe's law-governed unfolding is a

dynamism irreducible to sheer regular patterning over spacetime of familiar physical quantities (masses, charges, fields, curvatures, etc.). Furthermore, I strongly reify dynamism: spatiotemporally specific instances of it are a ``new'' realm of fundamental physical quantities, themselves dynamically interacting in their own right with other quantities (familiar or new). That dynamic interaction is a new level of dynamism, namely metadynamism, with its own laws explicitly mentioning dynamism instances. As causation is just dynamism, metacausation is metadynamism. The poster summarizes the arguments (revising earlier versions [1,2]) and sketches initial formalization steps for metadynamism. It also indicates how metadynamism might be co-opted to enrich other consciousness theories, notably IIT and Orch-OR.

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[4] Sebastian, M.A. (2012). Experiential awareness: Do you prefer ``it'' to ``me''? Philosophical Topics, 40(2), pp.155-177."

Poster titles and abstracts

Dominique Bourn

Math. Dept, Universit´ e du Littoral, Calais, France

“Talking cure” and polytopical aspects of consciousness modelling

The starting point for this work is a new reading of the case of Miss Lucy, from S. Freud’s Studies on Hysteria. His primary interest was that of understanding the origin of illness; we were rather interested in the logic of the treatment process which stand out remarkably by the final description of some undisputable form of somatic relief attesting that something compelling happened, which has yet to be understood: “After this last analysis, when, two days after, Miss Lucy visited me once more, I could not help asking her what had happened to make her so happy. She was as though transfigured. She was smiling and carried her head high”. This new reading has enabled us to delineate very clearly two psychic zones, and to outline their antagonistic relationships. We mean here preconsciousness zones, in the Freudian sense. We chose the term idiotope to designate these autonomous psychic instances which are constituted around axiological loads that have a degree of coherence and homogeneity, and around certain representations that are attached to them. But from one idiotope to another, there may be clear incoherences. Our working hypothesis is thus: if several idiotopes exist all the time in a given individual, at each moment only one idiotope is active; this is what allows a coherent perception of external reality. If the situation changes, another idiotope may be called upon. One of the advantages of this point of view is that it gives us a good hold on the plasticity of the human psyche. We may, of course, wonder about the insensible character of any change in idiotopic activation; it could be compared to the inattention that is given most of the time to the action of changing gears while driving.

Crisis situations would be thus characterized by the fact that external circumstances require accidentally the concurrent activation of two or more idiotopes. This multi-activation would then block any possibility to position oneself and would be the origin of psychic suffering. It is precisely the conclusion that we could derive from our reading. It is noticeable that some idiolectal recurrences are attached to the different psychic zones. A parallel could be drawn between this idiotopical attempt of conscious ness modelling and the mathematical Sheaf Theory which is interested in the conceptual mastery of the local/global relationship: if locally (above an open set) there can be continuous transitions, above a certain threshold these transitions become impossible. Some mathematicians have even taken an interest in articulating Sheaf Theory and Logic, and in attempting, from there, to unravel certain apories from classical logic.

Philip Clapson

Department of Psychological Sciences at Birkbeck, University of London

Consciousness and the theory of brain-sign

There is no question a brain phenomenon exists, commonly supposed as consciousness. But there is no scientifically agreed definition of it, or what it does. If the universe is wholly physical, it is incumbent upon any theory to demonstrate how consciousness can be physical and what precise role it plays in brain function.

In recent years I have proposed that consciousness be replaced by brain-sign. Brain-sign, the brain phenomenon, arises moment-by-moment from the causal orientation of the brain as interpreted by the brain. Its biophysical role is to facilitate communication between brains in collective action by establishing the common features of the world of the joint causal orientations, for brains are physical organs isolated in the body. Thus the world of action comes into being; but it is of course a neural construct.

Mental states are a prescientific myth, and their pursuit by neuroscience is counterproductive. The supposition that (for example) we 'see' as a mental faculty, or the brain sees, are errors. But it is not that the brain phenomenon is an illusion, as some authors propose, or that the brain tricks us. As yet science offers no appropriate model. Once established, mathematics is of use.

Brains are causal organs, not knowledge organs. In evolutionary development, the ability of isolated brains to communicate in joint action has improved survival chances, and facilitated inter-organism behavioural complexity, which in humans has transformed command of the environment, particularly in the last four hundred years with the emergence of science.

Explication of the theory does not involve the problematic notion of subjectivity. There is no mental world. The supposed mental subject, the 'sense' that we exist and command our actions, is each brain's identification of this organism in joint behavioural action. That is, it is part of the communication of brains and, as a sign, potentially identifiable in brain structure. (Signs are intrinsically physical and biologically ubiquitous.) Thus the presentation outline demonstrates that the process of interaction can be described in wholly scientific terms. Indeed, it is the fact of brain-sign that allows the communication of science itself.

The three components of brain-sign are (1) categories-of-the-world, (2) categories-of-interaction, and (3) brain-sign language. Each is derived from the causal orientation, and are established from infancy. They have no causal power for the host organism, but are the means of interneural communication. The first establishes the world of interaction; the second portrays the reaction of the organism to the world, including itself as organism; the third is the means of altering another brain's causal orientation. All these elements arise moment-by moment from the brain's causal orientation. They coexist, but they are not, as unconscious mental states, an alternative domain. How this takes place is the question for neuroscience.

Nicholas Edward Jung

University of King's College Vind. & University of Toronto

A non-reductive externalist model of consciousness

Many of the recent attempts to model consciousness focus on a reductionist internal modelling, concentrating themselves on the position that consciousness can be explained primarily through an exploration of the complex neurological functions of the brain. It seems though that such theories make little headway towards answering Thomas Nagel's question 'what is it like to be X'. What is of particular concern is that this failure appears not to be a failure of certain internalist models of consciousness but rather a failure of the internalist project itself, deriving from the fact that such theories have an inability to explain the content of one's thoughts. Following in the tradition of Tyler Burge's anti-individualism and Donald Davidson's anomalous monism, my project examines the role that language plays in the creation of conscious experience and will argue that the meaning of my language and, by extension, of my mental states is the product of the relation I have to the external world. I further argue that these external factors should not be reduced to a single unified law and are best examined as an irreducible Deleuzian rhizome. From these points I develop a non-reductive external model of consciousness, one takes into account the external socio-historical atmosphere that the conscious mind of X inhabits.

Robert Pepperell

FOVOLAB, Cardiff Metropolitan University, UK

Consciousness as a dynamical process caused by the organization of energy in the brain

To explain consciousness as a physical process we must acknowledge the dynamical behaviour of energy in the brain. Energetic flow is fundamental to all physical and chemical processes and causally drives all biological behaviour (Morowitz, 1979). The brain is a highly efficient consumer and regulator of energy (Shulman & Rothman, 2005). Recent neuroscientific evidence suggests consciousness is a product of the organization of energetic activity in the brain. Measurements of brain states following perturbation by Transcranial Magnetic Stimulation have been analysed using information theoretical tools and have shown that the complexity of energy flow in the brain predicts levels of consciousness (Casali et al., 2013). Substantial neuroscientific evidence exists to show that levels of recurrent processing, or internal feedforward and feedback loops, are strongly associated with the presence of consciousness (Edelman & Gally, 2013). On the basis of this empirical evidence, it is plausible to treat the brain as a complex dynamical system that is driven, not by information processing as is often claimed (Tononi et al. 2016), but by energy processing. Moreover, the scale and complexity of the recurrent processing occurring in the brain suggests the presence of high-order dynamical complexity, which finds an analogue in phenomenon of video feedback (Crutchfield, 1984). This relatively simple self-observing system generates emergent patterns of great fluidity, complexity and indeed beauty. An

opportunity now exists to combine mathematical modelling of such complex dynamic systems with empirical neuroscientific evidence to explore new models of consciousness based on the organization of energy in the brain.

James Peterson

School of Mathematical and Statistical Sciences, Clemson University

Consciousness models, bar code computations and cogntive dysfunction
In anesthesia, some patients experience the trauma of surgery despite being anesthetized. Such patients are called zombies and brain models to detect them using measurements available in the operating theater are needed. The altered state of consciousness obtained by the administration of drugs is similar to the altered behavior induced by a predatory wasp injection of neural cocktails into their prey. These external events reprogram the host into new behavioral patterns. Since the usual neural modules are present, these external inputs alter the connections between the neural modules allowing brain outputs to change. We use a simplified model of cortex- thalamus information processing with message passing/signal enabled asynchronous graph architectures using cytokine signals models as barcodes to model these events. The graph becomes a direct sum of subgraphs and consciousness state changes correspond to loss of entries in the direct sum representation. We discuss how the state of consciousness change could be monitored. Since the notion of normal behavior is important here, we discuss how to build a model of a normal brain using data so we can ask intelligent questions about how the normal behavior is shifted to the new state.

Jakub Vohryzek

University of Oxford

Connectome-Harmonic Decomposition reveals Brain's Dynamic Reorganisation after Psilocybin Treatment for Treatment-Resistant Depression
Psychedelic medicine has generated increased interest notably due to reports of clinical effectiveness in neuropsychiatric disorders including addiction, anxiety and depression. A recent fMRI study of psilocybin in treatment-resistant depression has shown promising outcomes with 50% of patients meeting criteria for treatment response 5 weeks after. The underlying mechanism by which psilocybin affects the depressed brain remains unknown, however. Here, we use a method called 'connectome-harmonic decomposition' – a spatial extension of the Fourier transform to the human connectome - to investigate the reorganisation of brain dynamics from pre-treatment baseline to 1-day post-treatment with psilocybin. After the treatment, we observed a reduction in the power and energy of high-frequency connectome harmonics, which was accompanied by a suppression of the repertoire of active harmonic brain states. Remarkably, the harmonic bands in which there was a decrease of energy and power after the treatment coincided with the range which has been found to show an increase in those measures under the acute effect of LSD and psilocybin in healthy individuals. These results therefore speak to a

potential post-acute ‘rebound effect’ in which post psilocybin treatment brain changes move in an opposite direction to those seen under the acute effects of psilocybin and LSD.

Andy E. Williams

Nobeah Foundation

A functional model for human consciousness

Other approaches attempt to identify the physical implementation of consciousness. This approach borrows the concept of functional modeling from software and systems engineering to define what is believed to be the most complete model of the functions of consciousness. This model is applicable to not only human, but also to artificial and collective consciousness, and has allowed this model to used to design social impact programs that leverage collectively intelligent cooperation to gain vastly greater capacity for collective social impact. Some key predictions of this work are: consciousness is a globally stable pattern in the dynamics of the internal state of the organism that enables it to switch between and therefore to consciously "choose" one of multiple globally stable patterns. This globally stability arises from a pattern of convection in the dynamics of well-being, where a functional model for this well-being is defined via a Semantic Metrics Framework, and where convection is modeled by the Lorenz equations for convection. Rather than a single “consciousness field” this model defines four “perceptual fields” (sensory, emotional, conceptual, and existential) through which the body, emotions, mind, and consciousness navigate according to chaotic dynamics governed by the Lorenz equations for convection.

Hye Young Kim

Ecole Normale Supérieure, Paris

Knotted space-time-consciousness

It is an attempt to explore a possibility to visualize the structure of time-consciousness in a knot shape. By applying Louis Kauffman’s knot-logic, the consistency of subjective consciousness, the plurality of now’s, and the necessary relationship between subjective and intersubjective consciousness will be represented in geometrical space. Kauffman introduces in his knot-logic linking as mutuality in the domain of knot set theory. A link in three dimensional space can be represented in three Reidemeister moves. They allow membership and self-membership in the corresponding knot set. I use the Borromean rings and trefoil knot to show the mutual membership expressed on their crossings to study the structure of subjective and intersubjective consciousness. Here, I show that how the self-membership of a link as in the first Reidemeister move ‘resolves’ the paradox of the self-contradiction of the primary observation of the self both as the observer and the observed at the same time, which also justifies the consistency of temporally distinguished subjective consciousnesses of the identical self.

Discussion sessions

Next to talks by invited speakers and participants, this conference will feature discussion sessions in parallel groups. The goal is to create an open and friendly atmosphere in which thoughts and ideas can be exchanged.

Each discussion session is devoted to one topic, either a specific question/idea related to models of consciousness, or a general question concerning progress and visions of the field as a whole. In addition to various topics which have been proposed in advance by the organizers and the advisory board, new topics can be added during the conference in response to talks or based on general interest.

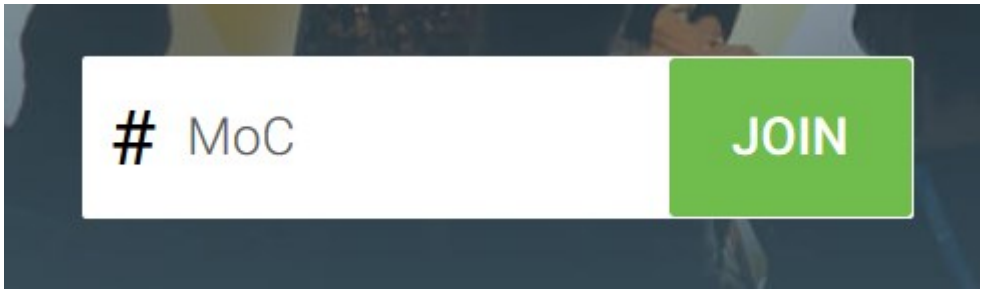
In order to let those questions emerge that receive the most interest by all participants, a web interface will be used, which allows attendees to indicate their interest in a question, as well as to propose new questions of their own. In order to access this web interface, simply access the following website with any internet device (laptop, cell phone, tablet)

www.slido.com

and enter the event code

#MoC

for “Models of Consciousness”.



How to use the web interface:

- In order to indicate that you find a question interesting, click the small “thumbs up” on the right hand side of a symbol.
- In order to add a new discussion topic, simply enter the question into the field at the top. (Please word questions carefully. If questions are not worded well, they might be blocked by moderators.)

The web interface is accessible also in advance of the conference.

Discussions are an integral component of science and we hope that the sessions held during this conference are enjoyable and fruitful. Ultimately, this

requires an atmosphere of trust and tolerance supported by all attendees of a session, much like described in the following two quotes by Isaac Asimov and a collaborator of Werner Heisenberg.

“First and foremost, there must be ease, relaxation, and a general sense of permissiveness. The world in general disapproves of creativity, and to be creative in public is particularly bad. Even to speculate in public is rather worrisome. The individuals must, therefore, have the feeling that the others won’t object. (...) It seems necessary to me, then, that all people at a session be willing to sound foolish and listen to others sound foolish.”
Isaac Asimov, *How do people get new ideas*, 1959

At the center of a discussion with Werner Heisenberg was “the shared problem and the desire to grasp and clarify it. One carefully approached it, passed it to the other, like in a friendly table tennis game, where both made sure that the ball remained in play. All the attention was focused on truly understanding the other and to avoid letting him stumble sophistically over his poor and inadequate expression. One could stutter, one could speak vaguely, even incomprehensibly, and he would guess what one actually wanted to say, would repeat it in his own different words, so that one could often exclaim with pleasure: ‘Yes, exactly that...!’. During such an (...) intense exchange of thoughts, the ideas and concepts sharpened, so that their contours became recognizable more clearly.”
A former collaborator of W. Heisenberg

Conference publication

On the occasion of this conference, there will be a special issue of the journal “Entropy” dedicated to formal models of consciousness. Participants and speakers are invited to submit their research, which will be peer-reviewed before publications.

Details on the special issue will be distributed to all attendees via email after the conference.

NOTES

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