Toward a Scientific Understanding of Consciousness

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Anesthesiology, Intensive Care and Pain Therapy Centre

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Agenda

1. Introduction and Problem Description
2. What is the Relationship between Brain and Consciousness?
3. Novel Approach to a Scientific Understanding of Consciousness
4. Implications and Conclusions
1 Introduction and Problem Description

2 What is the Relationship between Brain and Consciousness?

3 Novel Approach to a Scientific Understanding of Consciousness

4 Implications and Conclusions
Terminology and Focus

Consciousness

Phenomenal Consciousness
- Inner sensations and emotions
- Qualitative world of experience
- Qualia problem

Access Consciousness
- Mental processes, memories, reflections, contemplations, ...
- World of thought
- Intentionality problem

Main focus

(Block, 2005)
Qualia Problem (Part I)

- All our experiences in life are inseparably connected with our phenomenal consciousness.

- As complex biological organisms we not only process external stimuli. Rather, we also experience them in an inner world:
  - Fragrance of a flower,
  - Mellifluous voice of a singer,
  - Moment of happiness while viewing a sunset,
  - Emotional fireworks after achieving a top performance,
  - Agonizing pain after an injury.

- In a conscious state there is something that it is like to be in this state (qualitative aspects = qualia).

- That’s all very well, but …
Qualia Problem (Part II)

- How can it be that the physical and chemical processes in our brains are accompanied by subjective perceptions?

- In the scientific description of our world there is no pointer to the qualitative aspects of our lives.

- From a scientific point of view it is logically possible to imagine a system that works exactly like the brain but exhibits no consciousness.

- This means: the scientific understanding of consciousness cannot be completely reduced to physics → explanatory gap.

- This is the core of the hard problem of consciousness (qualia problem).

(Chalmers, 1995; 1996)
When did Consciousness Appear on the Scene?

Consciousness? 

Big Bang 

Particles

Atoms Molecules Complex structures 

Life 

Brain 

Consciousness? 

Consciousness

Galaxies Interstellar clouds 

Stars Planets
Guiding Research Questions

- What is the relationship between brain and consciousness?
- What kind of substrate is consciousness based on?
- What distinguishes conscious from unconscious processes?
- What are the fundamental mechanisms and principles behind consciousness?
- How can one determine the quantity and quality of consciousness of a given system?
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4 Implications and Conclusions
Option 1: Dualism

- The nature and structure of consciousness remains absolutely obscure.
- The interaction between matter and consciousness is mysterious (unknown bridging principles).
- We encounter an interface and causality problem.
Option 2: Materialism

- Hypothesis: consciousness “emerges” from large-scale activity patterns in the brain.
- However: all emergent phenomena in physics can be explained on the basis of weak emergence.
- In contrast, the emergence of consciousness from an originally unconscious system would require strong emergence (= magic).
Option 3: Panpsychism (Type 1)

- Hypothesis: Consciousness has always existed and is intrinsic to matter.
- If there are conscious and unconscious systems in the universe, a scientific approach has to explain the difference between the two types of systems.
- Moreover, we encounter the problem of how the rich spectrum of macro qualities emerges from a limited palette of micro qualities → combination problem.
Option 4: Panpsychism (Type 2)

Brain filters consciousness

Brain and consciousness reside in separate worlds

Most promising approach

Relationship between brain and consciousness

Brain assembles consciousness

Brain produces consciousness
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Overview of the Approach

1. All-pervasive ocean of energy = substrate of consciousness
2. Permanent interaction between brain and substrate
3. Interaction mechanism results in local modifications of the substrate (ordered states)
4. Ordered states go along with conscious states
All-pervasive Ocean of Energy

Classical physics

Quantum physics = classical physics + ZPF

ZPF = Zero Point Field
All-pervasive sea of light
Ocean of pure energy
Permanent activity

Physical systems are embedded in a void

Atomic orbitals
Stable attractor

Atoms are not stable
Interaction between ZPF and Matter: Impacts on Matter

- Components of Matter Interact Permanently with the ZPF

- Properties of Matter are Emergent Phenomena
  - The system components are stochastic oscillators driven by the ZPF.
  - The stability of a system is created dynamically as soon as the energy exchange between the system components and the ZPF reaches equilibrium.
  - Upon reaching equilibrium, a stationary system falls into a stable attractor and enters the quantum regime.

Presence of Matter Affects the Dynamics of the ZPF

- The characteristic frequency components (resonance frequencies) involved in the maintenance of the equilibrium become highly correlated.
- This leads to a “de-randomization” and partial organization of the local field.
- The formation of an attractor imprints a system-specific information state on the local ZPF.

(De la Peña and Cetto, 2001; De la Peña et al., 2009)
Core Messages of Eastern Philosophy

- All-pervasive energy field is the foundation of our existence
- All physical phenomena spring forth from this field through a transformation process, a dynamic flow of interactions
- Shades of consciousness correspond to modifications of this all-pervasive field

Interpretation in the Light of Quantum Physics

- Corroboration: findings of quantum physics agree perfectly with the world view of Eastern philosophy
- Hint: Mind and matter are based on the same substrate
- Conclusion: ZPF is an eminently suitable candidate for this substrate
- ZPF is the fundamental backbone of the universe and it is natural to assume that this backbone is charged with consciousness

ZPF is the carrier of consciousness.

(Eastern philosophy: Ricard and Thuan, 2004)
Neurophysiological Body of Evidence

- Conditioned stimuli are associated with specific activity patterns representing attractors in an attractor landscape
- Attractors are the NCC
- Vast collections of neurons shift abruptly and simultaneously between different attractors
- Rapid and efficient formation and dissolution of attractors resembles cinematographic frames
  
  (Freeman, 1991; 2005; 2007)

- Analysis of background activity shows that spontaneous oscillations in the brain exhibit 1/f power-law scaling behavior
- Brain operates in a scale-free state of self-organized criticality
  
  (Linkenkaer-Hansen et al., 2001; Freeman et al., 2003)

- Consciousness is associated with long-range coherence in the brain
- Synchronized activity in the gamma frequency band (gamma synchrony)
  
  (Crick and Koch, 1990; Engel and Singer, 2001; Melloni et al., 2007)

- Time-frequency analysis of LFP reveals that the source of gamma-band peaks is of stochastic nature
- Brain should be viewed as a resonant stochastic oscillator
  
  (Burns et al., 2010, 2011)

- Experiments investigating stochastic resonance (SR) imply that SR-mediated neural synchronization is a general mechanism of brain functioning
- Noise plays a fundamental role in the generation of gamma synchrony
  
  (Ward et al., 2006; Kitajo et al., 2007)
Brain operates near a critical point of a phase transition

Disordered phase / unconscious phase

Ordered phase / conscious phase

Irregular dynamics
Spontaneous activity
1/f scaling behavior

Appropriate stimulus induces an abrupt phase transition

Dynamics can only be understood on the basis of quantum physics

(Freeman, 1991; 2005; 2007; Freeman et al., 2003; Freeman and Vitiello, 2006)

- The brain is a resonant stochastic oscillator driven by the ZPF.
- Every attractor generates a specific correlation pattern in the ZPF.
Stream of Consciousness

Stimuli

Gamma synchrony

Desynchronization

Gamma synchrony

Desynchronization

Gamma synchrony

NCC in the brain
(macroscopic activity patterns displaying long-range coherence)

Attractor 1

Attractor 2

Attractor 3

Information states in the ZPF
(ordered states in the substrate of consciousness)

ZPF state 1

ZPF state 2

ZPF state 3
Every correlation pattern in ZPF information space corresponds to a phenomenal state in qualia space.

Calibration of ZPF Information Space

- Qualia space can be calibrated on the basis of first person accounts.
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4 Implications and Conclusions
Implication 1: Consciousness and Matter

- The conceptual framework provides an elegant solution to the mind-body problem.
- All the phenomena of matter and consciousness are based on one and the same fundamental substrate.
- The framework explains how matter and consciousness communicate in a causally closed functional chain.

ZPF orchestrates matter and is the source of the enormous diversity of physical manifestations.

Interaction process with matter generates ZPF information states that are the basis of our rich spectrum of qualitative experiences; a conscious moment is a ZPF information state experienced from inside.

(Keppler, 2012; 2013)
Implication 2: Consciousness and Information

- Conscious processes can be distinguished from unconscious processes in that only the former processes are accompanied by ZPF information states.
- The framework is able to specify existing approaches:

What sort of information state has phenomenal aspects?
ZPF is the substrate of consciousness, only ZPF information states have phenomenal aspects.

(Keppler, 2012; 2013)
Implication 3: Consciousness and Complexity

- Every system that generates ZPF information states may be conscious.
- All microscopic and macroscopic (nonlinear) quantum systems may be conscious.
- The number of different ZPF configurations (attractors) of a system determines the quantity of consciousness.
- The characteristics of the ZPF configurations (attractor dynamics) determine the quality of consciousness.

Simple systems have relatively sparse attractor landscapes with relatively simple attractors → they have a rudimentary form of consciousness

Complex systems have a very rich and highly adaptive attractor landscape with complex attractors → they give rise to a broad spectrum of conscious experiences

(Keppler, 2012; 2013)
Conclusions

The approach provides an elegant solution to the mind-body problem:

- Physical phenomena and conscious experiences are based on one and the same standardized substrate.
- By one and the same mechanism a system acquires not only its physical properties, but also its phenomenal qualities.

The approach …

- … avoids the “magic steps” required in Materialism and Dualism and explains how brain and consciousness interact in a causally closed functional chain.
- … solves the combination problem of Panpsychism: our vast array of phenomenal qualities is selectively filtered out of the full spectrum (continuum) of universal qualities.
References

- Freeman, W. J. (2007). Indirect biological measures of consciousness from field studies of brains as dynamical systems. Neural Networks 20, 1021-1031.