

Quantum spontaneity and the development of consciousness

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Abstract

The concept of quantum spontaneity is introduced to provide a non-deterministic model of consciousness that can accommodate our intuitive sense of self, consciousness, intentionality and willfulness.

Introduction

The nature of consciousness, its personification in the self, and its evident facility for intentional behavior remains an enigma and controversy in neuroscience and the philosophy of mind. Many leaders in the fields, scientists and philosophers, feel constrained by the scientific world-view to deny the reality of self, consciousness, and intentionality, and even those who grant consciousness an actual existence openly admit they cannot explain how it arises. Roger Sperry says “the general principles by which cerebral circuits produce conscious effects remain obscure.”¹ Daniel Dennett, author of *Consciousness Explained*, confesses without apparent irony that his “explanation of consciousness is far from complete.”² And John Searle, among the most circumspect philosophers of mind, is frankly baffled by “how anything in the brain *could* cause conscious states.”³

In taking my turn at a solution, I contend that the ultimate sources of the mystery can be traced to a needless philosophical dogmatism, and to what in this field at least is a detrimental compartmentalization of science: Deterministic “mathematical laws” serve well on the macro, or “classical” scale to predict and explain physical processes, but it is now widely recognized that a different mathematics is needed on the quantum scale. I believe that once the relationship between the two “worlds” is better understood and resolved, the nature of mind and the alleged anomaly of intentionality can become comprehensible and philosophically unobjectionable.

The Quantum and Macro Scales

Several theorists have looked to quantum randomness or indeterminateness as solutions to understanding consciousness and intentionality, but it has been difficult to explain how quantum effects, which already get constrained, averaged, or cancelled on the macro-physical scale, can be supportive of consciousness via higher-level neurological processes.

Quantum phenomena are often attributed to “randomness.” But given a precision-made coin-tossing machine and precisely minted coins, placed in a vacuum chamber and insulated from all outside influences, one can get *heads* 100% of the time. What is commonly attributed to randomness is actually due to interference by uncontrolled extraneous factors, to *conjunctive* influences. And on the quantum level there is no evidence of influences that could be interpreted as provoking “randomness.”

Quantum phenomena are also called “indeterminate,” but that term most expressly describes an obscurity in the *relationship* between observer and observed, not the quantum behavior itself. Alternatively, to call quanta “undetermined” is just a negative of what is thought to be *determined* on the macro scale – a presumption of an underlying physical vacuousness.

None such interpretations of the quantum level can be reconciled with the macro. They perpetuate the fundamental problem with quantum theory in its relationship with macro-physics, encouraging those with a specializing bias to consider the two “worlds” irreconcilable.

A conceptual bridge between the quantum and macro is available by means of the following interpretation: A cue ball is an aggregation of quanta, the behaviors of which are confined, averaged, and more-or-less cancelled in the whole. Undetermined or un-caused quanta, when brought together on a large scale, thus constitute causal systems, so that a cue ball, although comprised of individually chaotic quanta, when struck with a measured force at a given angle and spin, will cause a mathematically predictable result. Causality is thus a product of, *emergent* of, non-causal quantum behavior. Causality should therefore be considered a *derivative physical principle*, not a *law* of physics; as-such it needn't be treated as the foundation for a philosophy of mind.

So what is left of the presumption of mechanical determinism if causality is a by-product, what is the fundamental quantum principle if randomness and indeterminacy are dismissed, and what is the significance for the philosophy of mind?

I suggest that quantum events, if they are to be considered as they actually are, not (“indeterminate”) as they are observed, and not associated with randomness, can best be described as *spontaneous*. If quantum phenomena are tentatively regarded as such it provides a plausible first step in bringing the quantum and macro levels together to help disclose the nature of consciousness and intentionality. A world that is fundamentally spontaneous seems not so alien to a world of conscious beings. At the least, there is no obvious necessity that consciousness should be considered determined by what are merely derivative causal forces, nor as being produced by strange random/erratic processes.

A proposed association of quantum spontaneity with macro consciousness is not unproblematic. But before addressing those issues it will be helpful to examine the prevailing theories of mind that rely on causal physical properties, and consider their ultimate deficiency.

Dogma and Denial

Much of neuroscience and philosophy of mind is dedicated to a denial that subjective experience and intentionality exist. To believe in a purely physical and causal world is to believe that the mind must be a causally determined mechanism, and the most extreme among theorists are compelled to believe that alleged *peculiarities* like personal experience, feeling, and intentionality are somehow delusional, just impotent by-products of brain activity. Their belief is often supported by an ironically unscientific dogma that what cannot be objectively observed does not exist – a claim that cannot be scientifically tested and confirmed.

According to Dennett, “postulating special inner qualities that are not only private... but also unconfirmable and uninvestigatable is just obscurantism.”⁴ “The Self... is just an abstraction” says Dennett,⁵ and consciousness is just a “virtual machine”, “a huge complex” of neurological hardware, producing nothing but “complex dispositional states.” There is no self, he concludes, no “internal observer”⁶, and a complex of dispositional states is “all that’s going on.”⁷

Dogmatists like Dennett go to great lengths to prove that subjective experiences don’t exist, without ever touching on their first-person basis. They will deconstruct *sight* for pages and pages without ever spreading their fingers to look into the experience of *seeing*.

There are frank objections to such denials. Searle calls Dennett’s approach “a form of intellectual pathology.”⁸ He says of the extremists that they “end up by denying the obvious fact that we all have inner, qualitative, subjective states”⁹, and points out that “you can give a complete causal account of why we feel pain, but that does not show that pains do not exist.”¹⁰

David Chalmers is clear on the baseness of the dogmatic perspective, although his own positive characterization of consciousness exemplifies the hazard of veering into a mind/body dualism that make it impossible to explain how mind and matter could affect each other. He writes “we are surer of the existence of conscious experience than we are of anything else in the world”,¹¹ and argues that Dennett only shows it is possible to explain the manifestations of consciousness without explaining “the *experience* that accompanies” them.¹²

William James was already aggravated by the dogmatism at the birth of the modern field, criticizing the “intensely reckless” and “strange arrogance” with which “the wildest materialistic speculations persist in calling themselves ‘science’”.¹³ Galen Strawson says it “is the strangest thing that has ever happened in the whole history of human thought”.¹⁴ Thomas Nagel is willing to bet it “will come to seem laughable in a generation or two”.¹⁵ In answer to the claim that consciousness is merely a delusion, Roger Penrose makes a point difficult to evade: “If consciousness serves no selective purpose, why did Nature go to the trouble to evolve *conscious* brains when non-sentient automaton brains ... would seem to have done just as well?”¹⁶

It is remarkable that while trying to reduce subjective personal experience to an objective physical process, dogmatists seem to deliberately avoid discussing dreams. From their most severe bias, dreams don’t exist, they *cannot* exist – as they are subjective, personal, and objectively unobservable. And yet we know they *happen*. Dreams can involve fantastic experiences of things never seen, and words never spoken. In a dream, there is seeing but no actual sight. So are dreams not evidence of a mental life beyond objective “dispositions”? Nightmares can bring dreamers to a lurch from lying-down to sitting-up; do they not have causal powers?

Extreme materialism renders consciousness an inexplicable, delusional growth upon the world. Adherents are compelled to deny what cannot be seriously denied outside their gated philosophic community: our most immediate experience, the non-empirical but common representations of selfhood, our experience of pleasure and pain, our

sense of deliberately causing things to happen, our inner representations as in dreams and daydreams.

AI or AE?

The advent of “the computer age” has given hope to many that “artificial intelligence” (AI) can prove that consciousness is real but somehow reducible to physical processes, and that computers will eventually be indistinguishable from human minds.

Dogmatists like Dennett are ready to identify AI with consciousness as well, albeit of a limited nature. Of “the sort of difference that people imagine there to be between any machine and any human experienter”, he says “there is no such sort of difference”,¹⁷ and “in principle, a ‘suitably programmed’ robot, with a silicon-based computer brain, would be conscious, would have a self”.¹⁸

Searle and others don’t disagree that consciousness is a purely physical effect. Searle even believes that “there is not and cannot be any question whether a machine can be conscious and can think, because the brain is a machine”,¹⁹ but he argues that there is more to thinking than computation. His thought experiment of the Chinese Room²⁰ has shown that computing is simply a projection of human intension without intrinsic comprehension: A person in a blind room with no knowledge of a particular language (e.g., Chinese) can take inputs of incomprehensible script through a slot, process each according to a menu of rules, and output responses that can seem intelligent, although actually meaningless to the person in the room. This is precisely what automated computation involves: the oblivious processing of discrete serial instructions.

Responses to Searle’s experiment have been highly energized, even derisive. Nothing better exemplifies Dennett’s self-satisfied flights than his critique:²¹ He picks away at Searle without ever scratching the point that computation is devoid of comprehension. Searle, Dennett says, “is not alone in the room. There is also the System... and it is to that self that we should attribute any understanding”.²² He claims Searle’s Room relies on “misdirection”²³ and with unconsidered irony, he calls Searle a “conjurer”,²⁴ even as he himself conjures a “System” from a series of discrete instructions.

Chalmers offers a variation on the System idea, claiming “the ‘slips of paper’ processed in the room are not a mere pile of formal symbols. They constitute a concrete dynamical system with a causal organization that corresponds directly to the organization of the original brain”.²⁵

Steven Pinker, who defines the mind as “a naturally selected neural computer”,²⁶ explains in a chapter on “thinking machines”, that it’s all a matter of speed. “Searle has slowed down the mental computation to a range in which we humans no longer think of it as understanding (since understanding is ordinarily much faster). By trusting our intuitions in the thought experiment, we falsely conclude that rapid computation cannot be understanding, either.”²⁷

It is as-if the “System” (Dennett), or the *series* of instructions (Chalmers), or the *rapidity* of their processing (Pinker) is supposed to create a mind-like transcendent field of knowingness that unifies the instructions by spontaneous generation. This is a curious conception to be coming from self-professed materialists, but it is necessary for them to believe that a dynamic physical system of information-crunching is intelligent to some degree if consciousness is to be enclosed in a purely physical universe. For Chalmers,

even something so prosaic as a thermostat must have a rudimentary presence corresponding to the consciousness operating in more complex systems.²⁸

More reservedly, for the likes of Dennett and Pinker it is only allowed that consciousness is a holistic phenomenon, and as it must be a natural phenomenon, it follows that nature must constitute transcendent wholes capable of comprehending separate bits of information by a radical transformation, as at a tipping-point. Accordingly, there is thought to be a threshold, some sufficiently high level of complexity, involving billions if not trillions of elements, whereby *the virtual magic of virtual infinities* can metamorphose mindless bits and bytes to bring a computer mind into being. This begs another irony, and Dennett is willing to comply: “If your model of consciousness carries along nicely until the magic moment when you have to say ‘then a miracle occurs’ you haven’t begun to explain what consciousness is”.²⁹

Given the materialist requirement that mental transcendent wholes are recognized as a natural occurrence, biological organisms may plausibly be thought to create minds out of the interaction of cells, as they are inherently related, all descending from an original cell. But computers, no matter how complex, are simply manufactures, devices, put-together in ways that serve extrinsic ends. They can provide an expert level of resourcefulness, and thus manifest *artificial expertise* (AE), but to imagine they can constitute a holistic intelligence out of separate and indifferent parts is to forego scientific thinking for a divergence into the *magical*. (See also my earlier paper.³⁰)

Emergence and Supervenience

The denial of AI doesn’t require a denial of the plausibility of consciousness (“intelligence”) being a natural reality. For consciousness and intentionality to exist in a universe conceived in purely physical and biochemical terms, it would have to *emerge* like an enveloping field from elemental but connate biological or bio-synthetic interactions.

Searle defines “an emergent property of a system” as “one that is causally explained by the behavior of the elements of the system; but it is not a property of any individual elements and it cannot be explained simply as a summation of the properties of those elements”.³¹

The relationship between water molecules and the liquidity of a body of water is a popular analogy used to try to explain how consciousness could emerge from physics and biology. As Searle explains, just as “the liquidity of water is not to be found at the level of the individual molecule... visual perception and... thirst [are not] to be found at the level of... individual neuron[s] or synapse[s]”.³²

Searle goes to great lengths to justify consciousness as a naturally emergent system and to give it the legitimacy Dennett and others have tried to deny. “The logical nature of the *kinds* of relations between the mind and the brain” are not “at all mysterious or incomprehensible.” As with “the liquidity of water” they “are genuine features of the world not to be explained away and redefined or branded as illusory”.³³

At the same time, Searle wants to guard against any conception that might suggest a dualism of mind and matter, so he stresses that “consciousness is not a ‘stuff’, it is a *feature* or *property* of the brain in the sense, for example, that liquidity is a feature of water”.³⁴ Just as “solidity, liquidity, and transparency are examples of causally emergent

system features”,³⁵ consciousness is conceived as a systemic physical manifestation of elemental interaction.

Searle has come to be dissatisfied with the explanatory power of the purely physical analogy.³⁶ It is easy to see how loosely bound molecules interacting at a certain level of energy can slip by each other and produce, on a large scale, the emergent quality of liquidity. But the analogy breaks down when applied to consciousness. Liquidity is just a manifestation of objective relationships between molecules, but on a larger scale. A silica molecule might be transported by the buffeting of a cluster of water molecules, knocked loose from a stick of wood that is being buoyed down a creek by the same molecules as a body of liquid, and all that is comprehensible. But there is no such emergent transition from a network of firing neurons to a conscious experience of pleasure or pain.

Consciousness is not a system of extrinsic objective relationships; it is *intrinsic*, it has a subjective *interiority*. Thomas Nagel fully appreciates that the “experience of taste seems to be something extra, contingently related to the brain state.... So it cannot be identical to the brain state in the way that water is identical to H₂O”.³⁷ Strawson asks whether we can “hope to understand the alleged emergence of experiential phenomena from non-experiential phenomena”,³⁸ given that “the experiential/non-experiential divide, assuming that it exists at all, is the most fundamental divide in nature”.³⁹ With this idea of emergence there is just another inadvertent invocation of virtual magic, a transformation from objective interactions to subjective experience – as Strawson describes it, a “magic passage across the experiential/non-experiential divide”.⁴⁰

Sperry has offered an encouraging enhancement to the idea of emergence with the principle of supervenience, a sort of reciprocal causality whereby the whole reacts upon its components.⁴¹ Brain processes “encompass and transcend the details of nerve impulse traffic in the cerebral networks”⁴² and “elements in the brain ... are obliged to submit to... the overall dynamic”.⁴³ He offers the example of a wheel rolling downhill as an illustration of downward causal control: The wheel is given form and made solid by the interrelations among its constituent quanta, but they are correspondingly caught up and determined by the motion of the whole.

Applying the concept to an emergent/supervenient relationship between neurons and the brain, Sperry explains that “once generated from neural events, the higher order mental patterns and programs have their own subjective qualities and progress, operate and interact by their own causal laws and principles which are different from and cannot be reduced to those of neurophysiology...”⁴⁴

As a holistic reciprocal-causality, Sperry’s idea goes a long way toward satisfying our sense of being the authors of our thoughts and actions, “we” being the supervenient aspect in the causal reciprocation going on with our neuro-circuitry. We are not the epiphenomenal *observingness* in this innovative conception, but we remain epiphenomenal of the causal *doingness* even if we like to regard ourselves as freely intentional agents.

A further articulation of the supervenience idea has been developed with the “two-stage theory of decision-making”, which has roots going back to William James.⁴⁵ The explanation relies on some sort of “indeterminate” or “random” factors (we would say

conjunctive factors) providing the material for a directive mechanism in the brain to select from among the alternatives based on a complex of personal life experiences. Numerous variations on the idea have continued to appear, seeking to account for our sense of being causal agents, if only as the *causally determined* agents of *randomly determined* interpretations of *causally determined* events. Given our earlier deconstruction of randomness, conjunctive influences could be substituted for the randomness of the menu-generator, but the division of mind into a fluctuating menu of considerations worked on by a seemingly computational selection-generator only isolates the decision-making, it still doesn't break free of a foundation in determinism.

The quantum problem

Causal processes and the various forms of emergence and supervenience are unable to explanation consciousness and intentionality. Most theorists admit that they have no clue how the jump from objective processes to subjective experience can be made, just that if causality is to be saved, there must be a way, and emergence/supervenience is widely seen to be *the only way*.

I mentioned earlier that quantum-based alternatives to deterministic theories have been seen as means to somehow accommodate the apparently undetermined features of consciousness, but they have been problematic. There is the problem that quantum effects would seem to be already nullified at the molecular level, before they can influence conscious behavior. Another problem is the interpretation of quantum behavior as entailing indeterminism or randomness, which seems nothing like deliberate consciousness.

Penrose, a quantum physicist, "tentatively" imagines quantum mechanics to be the key to simulating the transcendent capability of human brains.⁴⁶ But by identifying indeterminate "micro-tubules" as the source of consciousness he is already locked-in to an explanation involving not only "indeterminacy" but also reductionism and emergence.

Searle initially found quantum explanations unsatisfactory for their supposed basis in randomness or indeterminacy, but he has more recently warmed to the prospect of some sort of quantum explanation, having concluded that causal explanations are inadequate in view of his abiding belief in "free will".⁴⁷ (We would say *willfulness*.) He says "quantum indeterminism is the only form of indeterminism that is indisputably established as a fact of nature",⁴⁸ and he is inclined to think that "the conscious experience of free will must be a manifestation".⁴⁹ But still, he has to ask "how do we get from indeterminism to rationality"⁵⁰ because "free actions are not random",⁵¹ which leads him to despair that the hypothesis of free will (i.e., *willfulness*), however compelling, "is a mess."⁵²

It is to these problems with quantum explanations of consciousness, and to those of denial and determinism, that I believe the concept of spontaneity provides an alternative and solution.

Spontaneity

The concept of spontaneity suggests independent, uncaused behavior that expresses an inner dynamic. At the quantum level the dynamic may be so simple, and its means of expression so extremely limited, that there is no practical reason to distinguish it from "uncaused." But if quantum spontaneity is to be somehow linked with consciousness, an

inchoate inner dynamic at that level will be seen as related and natural, although highly developed and manifest at the larger level.

In any case, spontaneity is the least biased interpretation of quantum phenomena. The idea of quantum randomness is derived from a belief and bias for *no-cause*. The idea of quantum indeterminacy is derived from an indefinite belief in either *no-cause* or *no-observable-cause*. Implicitly at least, both ideas are biased against a consideration that quanta might have an autonomous dynamic, which could be described in contrast to the others as *auto-cause*. The idea of quantum spontaneity derives from the observation that there are no evident external influences, and any interpretation other than autonomous dynamism (i.e., spontaneity) would be a presumption of *no-cause* – which would actually be the explanation best suited for nothing happening at all.

The question is this: Given the problems entailed by determinism, and the conceptual disconnect between the quantum and macro realms, and the incongruity between the conventional descriptions of physical and mental phenomena, what can *spontaneity* offer besides being the most plausible explanation for quantum behavior? What can it explain about consciousness and intentionality that cannot be otherwise explained?

It is to that question that only a significant revision of the prevailing metaphysic can provide guidance and insight, as the metaphysic currently in ascendance conceives only of smaller causal systems causing larger causal systems, while more or less ignoring the quantum discrepancy.

An alternative metaphysic

For spontaneity to be recognized as a natural principle that both characterizes quantum behavior and induces consciousness, an alternative metaphysic must trace a coherent path between them.

If we share a fundamental spontaneity with the quantum and possibly other natural bodies, one common feature that seems essential is what can be thought of as unity, or wholeness, or individuality. The quantum is considered to be an individual; it is by definition the most basic individual entity. The atom and the biotic cell, and of course a neurological being all fit the definition of individuality as well. These could be the nodes, or levels, where individuality is consolidated.

We need also to discover a connectedness between levels of individuality in order to establish a continuity from quantum to human. We've already seen that conglomerations of quanta seem to break the chain we're looking for: Sperry's wheel, a causal, deterministic object, constrains the spontaneity of its constituents. But individuals at a given level can also combine as dynamic elements of structured aggregates – the biotic cells of a larger organism, for example. This should be the key to continuity: A conglomerate of spontaneous individuals becomes mathematically predictable, and more strictly causal, the larger it is. But individuality at a new level can be created by the systemic, aggregate interactions of highly structured individuals at the already established level.

Consider this simple model: Spontaneous individuals generally interact in chaotic ways. Some become constrained in conglomerates, some become elements of structured dynamic aggregates. Structured aggregates may evolve into more complex and organic systems, and in some cases establish a higher level of unity. This new level constitutes

larger, more complex spontaneous individuals, as cells do of atoms, and as animals do of cells.⁵³

From quanta to atoms to cells to (neurological) animals, and all the aggregates that mediate and comprise them: This is the comprehensive continuity that the concept of spontaneity can provide. It is a model of emergence, but it is an emergence of like-to-like, not object-to-subject. And it dissolves the distinction between mind and matter without reducing one to the other.

Causation and Intentionality

An important recognition provided by the distinction between aggregates and individuals – already mentioned abstractly in terms of Sperry’s wheel, but now framed in a metaphysic – is that causality is specifically characteristic of dynamic aggregates and conglomerates (i.e., unstructured aggregates). The behavior of individuals, being spontaneous, is to the extent that they are structured and effective (compare quanta to humans), they are *intentional*. And intentionality, although it can be causal in its effects, and can be influenced by systemic causes, is when fully developed, *willful*, and willfulness in-itself, is (because it is spontaneous) uncaused. Thus, in principle: Aggregates are causal and have effects; individuals are intentional, and have objectives.

The terms “intentional” and “willful” may seem anthropomorphic when applied to all levels of individuality, but not if we grant that they are exercised in prior levels only as effectively as their structures allow. Evidence of spontaneity must be sought to be found: Already Martin Heisenberg’s research indicates “evidence of randomly generated [spontaneous!] behavior” can be seen even in unicellular organisms (i.e., biotic cells) and fruit flies.⁵⁴

Emergence or Convergence?

The metaphysic sketched here may be considered coherent and plausible (or not!), and yet it relies on *emergence* – not on the magical, but still, on the discontinuous. Even the transition from systemic *individuals* to a transcendent *individual* is a leap.

I propose an additional aspect to this metaphysic: that a more plausible explanation for what is conceived as emergence is *convergence*.

It is recognized in particle (quantum) physics that space isn’t empty, it is roiling with “virtual particles.” Given the continuing problem with emergence, it seems more plausible that the source of spontaneity is ubiquitous, although not necessarily extant. But given a viable structural framework *Nature* could converge, and become focused and dynamic in individuality. When *Nature* is instantiated in a brain, it is what we experience as *consciousness* and *intentionality*. As a convergence, brain function doesn’t *cause* consciousness, it *enables* it.

Conclusion

The most immediate relief offered by the metaphysic of *spontaneity* is it allows our subjective experience, so incompatible with the dogma of determinism, the potential for affirmation. It can also be liberating for materialists from the dogma of determinism, and the strain of denying our most intimate sense of self, consciousness, intentionality and willfulness.

Citations

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- ² Dennett 1991, p. 455.
- ³ Searle 1997, p. 193.
- ⁴ Dennett 1991, p. 450.
- ⁵ *ibid*, p.368.
- ⁶ *ibid*, p. 431.
- ⁷ *ibid*, p. 459.
- ⁸ Searle 1997, p. 112.
- ⁹ *ibid*, p. xiii.
- ¹⁰ *ibid*, p. 31.
- ¹¹ Chalmers 1996, p. xii.
- ¹² *ibid*, p. 105.
- ¹³ James 1890, p. 454.
- ¹⁴ Strawson 2006, p. 5.
- ¹⁵ Nagel 2012, p. 128.
- ¹⁶ Penrose 1989, p. 408.
- ¹⁷ Dennett 1991, p. 375.
- ¹⁸ *ibid*, p. 431.
- ¹⁹ Searle 1997, p. 110.
- ²⁰ Searle 1980, etc.
- ²¹ Dennett, 1991, p. 435ff.
- ²² *ibid*, p. 439.
- ²³ *ibid*, p. 435.
- ²⁴ *ibid*, p. 436.
- ²⁵ Chalmers 1996, p. 325.
- ²⁶ Pinker 1997, p. 521.
- ²⁷ *ibid*, p. 95.
- ²⁸ Chalmers 1996, p. 293.
- ²⁹ Dennett 1991, p. 455.
- ³⁰ Arnold 2994.
- ³¹ Searle 1997, p. 18.
- ³² Searle 1983, p. 268.
- ³³ *ibid*, p. 267.
- ³⁴ Searle 1994, p. 105.
- ³⁵ *ibid*, p. 111.
- ³⁶ Searle 2007.
- ³⁷ Nagel 2012, p. 41.
- ³⁸ Strawson 2006, p. 13.
- ³⁹ *ibid*, pp. 17-18.
- ⁴⁰ *ibid*, p. 13.
- ⁴¹ Sperry,1965.
- ⁴² Sperry 1969, p.533.
- ⁴³ Sperry 1966, p. 4.
- ⁴⁴ Sperry1965, p. 201.
- ⁴⁵ James, 1884.
- ⁴⁶ Penrose, 1994, p. 376.
- ⁴⁷ Searle 2007.
- ⁴⁶ *ibid*, p. 74.
- ⁴⁷ *ibid*, p. 74.
- ⁴⁹ *ibid*, p. 75.
- ⁵⁰ *ibid*, p. 75.
- ⁵¹ *ibid*, p. 75.
- ⁵² *ibid*, p. 77.
- ⁵³ Arnold, 1996.
- ⁵⁴ Heisenberg 2009.

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