# DOWNWARD CAUSATION: CONTROL THEORY, SYMMETRY BREAKING, QUANTUM FIELD THEORY, AND NEURODYNAMICS

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ABSTRACT: There is considerable consensus that any putative new paradigm for biology will involve control theory as a means to traverse hierarchies. There is considerably less consensus about how a disincarnate observer can initiate a chain of downward causation starting with a quantum mechanics measurement and propagating down to palpable effects, not just in the motor system but in the intricate connections between the immune and nervous systems. In this paper, we begin by outlining the Bionoetics framework in a historical context and continue by formalizing the interaction between the brain considered as a large set of basins of attraction (or quantum field theory ground states), the differential readiness of neurons to fire described in neurodynamics, and the motor system. We go on to describe the traversal of hierarchies in living systems that mean ultimately that there are different "biologies" to formalize at each level. Finally, we speculate about the pervasiveness of the causal effects of human intention.

KEYWORDS; Order parameter; Fields; Symmetry breaking; Hierarchy; Control theory; Bionoetics

## INTRODUCTION

One reason for the unreasonable INeffectiveness of math in the biological sciences may in fact be that there exist myriad "biologies" each corresponding to a level on the hierarchies. This applies a fortiori to neuroscience, with the added caveat that the brain's functioning seems also to be informed by laws pertaining to observer status in physics. Not only is the brain an exceedingly complex biological system in its own right; its functioning as mind means that it is capable of arbitrary levels of hierarchy as

humans are capable of arbitrary levels of abstraction.

Complicating things further – and, yes, it will be a busy century (if not millennium) in biology – the fact that we are about 70% water with fully 99% of our molecules being $H_2O$, the light molecule most susceptible to quantum effects. Pioneering work in many-body theory has established the possibility of Bose-Einstein condensate formation in the cortex; it is likely that the downward causation from mind to body so desired by John Eccles and others can thus be mediated, with perhaps unexpected medical implications. This can be construed either with many-body analysis of the water dipole or with field analysis of what is effectively an ionic plasma, or both.

Therefore, it is conceivable that downward causation - a causal relationship from higher levels of a system to its lower-level parts - is implemented in hierarchical networks of the human brain, and in other nets of different kinds. Not only in networks of neurons, as mainstream neuroscientists actually believe, and Silicon Valley engineers posit in their deep neural networks implementations, but also in networks consisting of other entities such as water dipoles.

Clearly, water cannot be neglected. Water matters! The biology of water has much to say about neurodegenerative disorders such as Alzheimer's Disease and other diseases driven by the hydrophobic misfolding and aggregation of proteins. Water offers an important avenue for medical attention and the biophysics of distinct forms of water, especially in the close and distant neighborhoods of membranes with fluctuating ionic concentrations associated with the electrophysiology of brain dynamics. Better understanding of water may suggest medications or other interventions for diseases of aging.

With this paper, we argue that control theory may provide a mathematical framework to integrate these findings. Control parameters are being transferred from one level to the next level within and between hierarchies, i.e., from water molecules to integrate and resonating neurons. It flows from microscopic, minuscule temporal scales to macroscopic spatial and temporal scales. The final destination may be the abstractions that humans normally perceive.

Our notion of downward causation unifies two primary themes:

1. How thoughts can have effects on the material world through quantum field theory processes, and

2. How control theory can be imported into biology in a principled way for hierarchies and layers.

Beginning with an historical introduction, we intend to provide a more accurate mathematical description of our current state-of-the-art knowledge of brain/mind

dynamics.

## DISENCHANTMENT AND RE-ENCHANTMENT; FROM ZWINGLI TO BIONOETICS

In the teens of the 21st century, it became clear that there were fundamental flaws in our approach to some critical problems in science. The problematic preponderance of mysterious dark matter and dark energy in the cosmos was merely a prelude to crises in the biological sciences. Neuroscience had reached an asymptote; even given a wiring diagram as in the case of *C. elegans*, a generation of research had failed to divine how the organism worked, or why some neurons never fired. The status of "Gene" became problematic, as saving the phenomenon required positing dark areas of non-coding DNA that paradoxically were efficiently causal. This became a situation to be reviled by computer scientists for whom coding was what they lived and breathed.

Yet that was hardly even the tip of the proverbial iceberg. The failure to establish a privileged position for the normative resulted in rampant relativism in ethics and aesthetics, with greater resultant problems for the rest of society than academics felt inclined to admit. Into those vacua rushed economization and its trumped-up sibling "financialization"; tenured academics who might have used their privilege to question why those who caused the crash of 2008 were so richly rewarded for doing so were staring at the DJ to a sampled soundtrack instead of going to the barricades. As for assertion of values that might be called "sacred", the impossibility of so doing in western academies left the field open for fundamentalism.

We can trace the history of the issues involved to reformation Europe through the enlightenment onto the failure of philosophers of science to deal with the supercession of classical physics by quantum physics. On the one hand, the computational necessity for asserting a great chain of being appeared with redefinitions of computation and information at each level; on the other, a nuancing of the Cartesian split between subject and object was proposed, present still in acceptable versions of quantum. While subjectivity, it is argued, is ineluctable, the contents with which that subject chooses to identify are variously the province of the arts, the sciences and religion. Moreover, the facts of transcendence, will, ontological distinctions and the desideratum for formal adequacy in Neuroscience leads the 21st century in directions not previously countenanced.

In particular, the quixotic quest for a "science of experience" (Reed, 1997) has undermined us. In that scenario, experience occurs when the mind-world relationship involves events of sufficiently slow duration (about 0.1 second or greater). In that case, there is a certain limited role for psychology – and indeed psychoanalysis, if a troubled

past has come to light. Otherwise, the "science of experience" must wait for the normative structures that determine subject-object relationships to be applied. In short, for sensorimotor, as for mathematical "noetic" existence, there is essentially no experience. Only in the cognitive realm, founded on mental events of 0.1 second or greater, is there experience and associated with this the entire structure of the arts, religion, social sciences and the laws and mores of our societies.

Religion is above all consensual experience of the sacred. Normally this is experienced in the context of an encompassing reality that we call God. The genius of the Abrahamic religions was to make the god eternal, absolute, ubiquitous – and yet invisible. He (always He) could also be experienced in the deepest recesses of one's psyche. He could be invoked with suitable ritual to shower his blessings on a situation, if necessary to shape it toward the wishes of the celebrant.

The response to what is now called neoliberalism and previously went under other guises was classically Marxism incarnated as utopian socialism. As the last explicitly socialist states succumb to their own structural failures and attacks of economic hitmen, nationalism is becoming an antidote. Khomeini argued that the redistributive ethos of Marxism was already present in Islam; in Houllebecq's (2015) "Soumission", the argument is made that liberal individualism is an all-devouring fire that eventually attacks the family, making society unsustainable, at which point Islam enters with its eternal Koran, out of time and space.

The struggle against Yahweh occupied many of the finest spirits in the West for several centuries. From this struggle emerged freedoms of conscience, association, action and expression hitherto unknown in human history. The attempt by Islamic radicalism to turn the clock back is quickened by the need of neoliberalism to import fast-breeding populations into Europe sustain their economic systems threatened by collapse of their populations. Let us look at the thought of one of the finer of those spirits, Zwingli. (all quotes are from Uberoi, 2002)

"I hold that the sum total of Zwingli's revolution was (a) to divide the world of spiritual truth and the inner light from the world of apparent reality and outer forms and (b) to insist that the two spheres of existence and experience, the inner and the outer, never meet for man in this as against the next world…the new Christian would no longer seek to transcend the duality of the spiritual and the temporal through ritual and the church as in mediaeval Europe, but rather, if at all, through the word in the chapel and work in the world (34)"

Roman Catholic theologians are prone to blaming Luther for the crisis of authority that give rise inter alia to Marxism and its failed projects of utopian socialism. In "Zwingli and the new religion", it is argued that Luther was far less, and Zwingli far

more radical than heretofore thought (26);

> "The shortest way I know to define and explain the new regime or structure as a whole is that it rested on two fundamental presuppositions; (a) the dissociation and the autonomy of fact and value in the field of knowledge; (b) the dissociation and the autonomy of …belief and conduct in the field of life."

It is argued that Luther's pre-eminence over Zwingli arose because of the latter's failure to attract secular support. However, it is the latter to whom it was given "to expressly formulate the new system of interrelations between God, man and nature, which in turn produced…the sciences of man and the science of nature…In other words, positivism as a faith and a system in the wide sense first arose in Europe…over the question of the place of God and the sacred in the world-view and the life-world of man" (26)

The contrast with the pre-Zwingli era is stark (ibid.);

> "Up to and including the period of the Renaissance, it seems any European could pursue knowledge of the true, the good and the beautiful conjointly as *scientia* as did Leonardo…"

This study was done in the context of a cosmos considered as sacred (ibid. , 31);

> "Before the schismatic revolution, the whole visible cosmos was the body of God, more or less, and it had to be viewed as such."

Clearly, currently the level of environmental destruction requires that we find a new way to sacralize Gaia given that this pantheism was a victim of Protestantism; Descartes is often cited as another villain here. We shall not concern ourselves with the battleground Zwingli chose which was the mass other than to say (25);

> "The focus of the Reformation…was upon the question of the liturgy ie the mode of the presence of divinity in Christian ritual…the respective positions may be called transubstantiation, consubstantiation and non-substantiation" where the last option is Zwingli's. Indeed, he forbade celebration of the mass, believing that the Word of God represented to the person by declamation of the Bible was the only truly valid way to form the soul. Contrast Aquinas, for whom the Eucharist was (32) "the central pillar of the church…so that the Lord was present whole, entire and perfect in every fragment of the symbolic species."

Moreover, for Aquinas in 1264 "the sacrament of faith affected the body as well as the soul; it restored health and vigour to the sick (30). To deny it involves one in rending the mediaeval notions of temporality and eternity as well as the more prosaic question of symbol and reality" (28);

> "By stating the issue and forcing it in terms of dualism, or more properly double monism, Zwingli had invented the modern concept of time in which every event

> was either spiritual and mental or corporal and material, but no event could be both at once."

Uberoi (35) argues that the issue of the Eucharist was effectively a stalking-horse for a more comprehensive reparse of nature, man and society. The response of the Catholic church was ultimately a grudging surrender to the presence of time and a disenchanted cosmos;

> "the Pope's new doctrine now wholly removed, just like the Protestants to whom it was a response, the pantheistic element from the nature of the world…..the new ritual of transubstantiation was to be a kind of miraculous transference by God's agency between teo separate planes and two different times."

Uberoi is chasing still bigger game (39);

> "I may somewhat simplify the structure of the modernist regime by saying its two fundamental axes were the division between fact and value on the one hand…and the division between… theory and practice on the other…. My thesis is that this is the elementary structure of the modern positivist regime as a system."

This system, which he attributes to the Saint-Simonian who preceded Auguste Comte, defines the relationships between this disenchanted science and society. It has led, Uberoi argues, to a catastrophe when it comes to the assertion of subjective existence (41-42);

> "The present policy of man the scientist was to divide and conquer the external world now and save the internal world, hopefully still intact, for the kingdom of God to come. It is as if a man were to insist in a fit of insanity …that he himself, the knower, was merely a subjective value unfit to be include in his own scientific discourse."

We are, according to Bionoetics, now in a position to resacralize nature, to reintroduce the reality of thaumaturgy in the context of ritual, without sacrificing "techne", instrumental science. Indeed, by insisting that techne become "episteme", deeper understanding, and by elaborating an ontology and appropriate metaphysics, it is possible to create better science – even better techne. Let us try and summarize the viewpoint arrived at.

In the early 21st century, it is no longer vacuous to posit an entity that is eternal, absolute, ubiquitous – and yet invisible. We have succumbed to the notions of creation from a point in space and time at vanishingly low entropy. Bizarrely, quantum mechanics allows the capacity for invocation and incantation to change a situation by action at a distance if only in very limited contexts where indeed an observation can change things in the present and to some extent in the past.

We have no idea how this relates to ordinary cognition and, as of the teens of the 21st century, nobody does. What we do know is that 99% of the molecules in our bodies are water, a dipole with separated spatial charge. We can also construe much of the brain as intermittently permeated with ionic plasmas. In either case there suddenly is a possibility for quantum phenomena in human brain biology, whether construed in the terms of many body theory or calculated by an extension of the Vlasov-Maxwell equations. The former is the leitmotif of Walter Freeman's final period with his colleague, Giuseppe Vitiello; the latter is work by Zhen Ma.

In either case, there is now a capacity for top down causality from the "mental" to the "physical". Thought can change neurodynamics structures, leading ultimately to biochemical changes at all levels of the human organism. Freeman's labmate, Richard Strohman, attempted several statements of possible types of hierarchies and we include two previously unpublished ones here. The question of which is correct we leave open.

Consciousness always involves the presentation of phenomena to an observer. Consequently, its contents are normally part of social science. So far it has been unfortunately mainly been studied scientifically only in the context of anesthesia, with a pious hope that the result will have something to do with trans-Turing computation. The study of Consciousness, as distinct from its contents, would seem to be limited to the old saws of analytic versus intuitive modes (yang/yin, etc) and possibly more systematic analysis of how psychedelics distort content.

One major problem with Yahweh/Allah is that he discourages impartial and cogent scientific inquiry. Following Aristotle, we can term this movement of the psyche together with skills as "techne". The over-emphasis on techne is what makes perennial *les enfants terribles*, the savants and their output in Silicon Valley so boring. Otherwise put, as the classic statement of the frame problem in AI goes, mere techne allows the playing of a brilliant chess move while the building is on fire. We can term "episteme" the wisdom that tells us to flee, and follows the adage that a movie in which every scene is brilliant will be boring.

Following the Bionoetics categorization, we can term techne "coupled" and episteme "decoupled". We can become conscious of mental events that last more than a tenth of a second or so; the Bionoetics argument is that our societies restrict themselves to such events in education, organization and administration. Those sports of nature like the young Mozart who clearly do not learn in this manner are the forerunner of AI systems.

We can indeed construe ultimate Reality as uncreated, Absolute, ubiquitous, low entropy, an undifferentiation of subject and object, being itself in that it is infinite energy at infinitesimal levels of entropy (Ó Nualláin, 2018). It is clearly already

partially realized through our vast cosmos, and the extraordinary beings that we and our whole Gaia system are becoming.

As manifest in us, ultimate Reality seems most closely related to attention; in our moments of self-transcendence, when we briefly get a sense of ourselves as object, we perhaps come closest to experiencing its necessarily impersonal essence. It is an empirical fact, which even the bloodiest minded of the new atheists cannot gainsay, that we are vehicles for the cosmos to know itself.

There are many counter-cultural activities which are redolent of invocation of the absolute in the sense just introduced. Kids learn classical music in an age in which rap has destroyed the musical sensibilities of two generations; adults spend small fortunes on instruments whose tonal superiority to others is discernible to few and sit for hours at events in which mediaeval and classical music is played.

Talented youth form bands, thus totaling a decade of their lives; the academically best such spent similar spans doing PhD's in subjects like anthropology and philosophy with no chances of getting jobs. Equally fine spirits get drawn into so-called ecodefense, caring for the genetically hopeless, and reporting from war zones only to find profits from their reporting go to Facebook and Google through ads.

This paper is an exploration of what is happening in such situations. Are we changing the cosmos? Are we deluding ourselves? Or is there implicit a new unveiling of Reality, one that we currently describe with resources like quantum field theory as veil after veil are lifted? Is the ending of the category of perlocutionary speech acts with their incitement to action premature? Is their future invocation also a possibility?

As for the sacred, should it not be clear to us in the west that our victories over the priests of Yahweh – democracy and privacy in particular – are sacred? It is clear that science as technology works, so that does not need protection; however, the existence of ontological divisions in nature is a subtler point. Where Islam excels, and the reason it may yet prevail in the West, is its assertion of the sacred in the quotidian activities of life like procreation, entry into the community, and regular immersion in the Absolute ground of Being that western science cannot encompass.

For that, we need a sense of the Transcendent, first of all construed as something Absolute, that is, not relative to anything. As it unfolds in our individual lives, we find ourselves growing in social, political aesthetic and other realms, first in a sense of a Reality transcendent to us, and later in a personal appropriation of that Reality in an appropriately honed sense of self. The intellectual formation necessary to understand this in outlined in Bionoetics as science; its incarnation in suitable forms of life awaits the arrival of properly-resourced hierophants and their followers.

In summary, by following the dictates of the objectified nature we inherited from

Zwingli, Francis Bacon and Descartes, and others, we seem to have chanced upon a clearing where magic is afoot. We are the result of creation from a single point; the universe is absurdly ordered; Gaian processes support our every breath, Science itself requires a more elaborate ontology, with sharp distinctions between the quantum classical, and biological to start with.

As for us, we seem to be able to change reality with pure thought, *pace* Zwingli. Then the epistemological subject needs to be unpacked into decoupled modes involving intentional, relativistic and determinative capacities. Corresponding to each of these are qualia; but these remain the province not of a science of consciousness, but rather of a properly construed sociology, aesthetics and what can only be described as "moral science". In short, the schema that Zwingli so valiantly combated, losing his life in battle, is back, but transformed to allow freedoms of thought, action and association, and prohibiting arbitrary authority.

It is our view that the weakest part of Uberoi's argument is his effort to rehabilitate Goethe's quixotic attempts at a theory of light and color. Specifically, Uberoi wishes to nuance the subject-object relationship in western science, using this as key. We believe that our framework allowing coupled and decoupled subject-object relationships unties this knot more informatively, and in a manner that suitably exploits terms like "intentional and "relativistic" that are commonplace in modern science.

In short, Bionoetics is *scientia* reinstated. It asserts an ontology other than the simple Zwinglian, such that will can be instrumentalized as decorrelation and sparsification of neural impulses, and by way of diagonalization in QM; it proposes that at a certain point in evolution, the brain acquired physics observer status, with downward causation as shown in this paper being one result; an inheritance of attributes from the physical to the biological; new in biology are formal causality, syntax and semantics, as well as the cell and other classical biological artifacts.

The kind of scientific projects we propose are exemplified by this paper; we hope to extend our work on the individual neuron as an harmonic oscillator, the use of homoiconic programming languages in genetics, the field in neuroscience as exemplified by the attempt to read the Bose-Einstein vector field from the scalar EEG field, and a systematic investigation as to how the brain emulates formal math techniques.

As a spirituality, it argues for the sacredness, as distinct from the convenience, of western freedoms; it accepts that there is a "spiritual path" involving grappling with the numinous through the body; it argues for western sacred art, whose signatures include the stack depth of the symbolic structures used and the sheer counter-cultural effort involved; the re-enchantment of nature can start with QM and extend to Gaia. In

short, the disenchantment initiated by the Reformation is to be reversed, while preserving its gains of individual freedoms and a more veridical science.

## QUANTUM FIELD THEORY AND MENTATION

Toward the end of his long and illustrious career, Walter Freeman became open to the use of Quantum field theory (QFT) for the formalization of brain processes (Capolupo et al., 2013). Therein lies a tale and we must unpack precisely what we mean by QFT and its application.

First of all, QFT can be considered primarily as a set of techniques looking for an application. So, we can regard quantum electrodynamics as an instance of QFT. We can similarly regard the formalization of neurodynamics of the late Walter Freeman as another instantiation (ibid.). In particular, there seemed to be an elegant mapping from basins of attraction to QFT ground states, and from the tumult following the selection of such a basin, resembling streams turning into a torrent in winter, to vortices in QFT. Following this initiative came attempts by writers like Piattelli-Palmarini to apply it to language. We believe this approach to be fatally flawed for reasons we now explain.

Aside from being a body of techniques, QFT is a theory of the physical world, excluding only gravitation. The situation is described by Stapp (2017, P. 119):

> "It must be mentioned that in the late 1940's physicists (Tomonaga/Schwinger) created 'relativistic quantum field theory (relativitistic QFT)."

Stapp (ibid., 107) is concerned about how the Q+A of a quantum mechanics experiment can be construed:

> "In orthodox Tomonaga/Schwinger relativistic QFT the quantum state collapses not on an advancing sequence of constant time surfaces…..but rather on an advancing sequence of space-like surfaces…..the new 'effective past' is the past that smoothly evolves into the …quantum state (of the universe) that incorporates the effects of the psycho-physical event that just occurred…this sequential creation of new 'effective pasts' is perhaps the strangest feature of orthodox quantum mechanics (QM), and the origin of its other strange features."

So, the user is causal, molding even the wave function of the entire universe, expressed in a density matrix. More specifically (ibid, 109):

> "Of course, one cannot know the density matrix rho of the entire universe. The orthodox rules tell us to construct a 'reduced' density matrix by taking a partial trace over the degrees of freedom we are ignorant and renormalizing" (renormalization is a key math trick in QFT to get rid of infinities).

So, let us recap. QFT is, on the one hand, a hired gun, a bag of tricks that can be applied to diverse areas from language to neuroscience. On the other hand, it is also

the most accurate theory of the physical world ever devised, excluding only gravitation, as it results in the most accurate predictions in the history of science; by one account, the electron's magnetic dipole moment has been calculated to 15 decimal places, and observation has confirmed this.

So why not use it for language and other acts of mind? There is indeed no reason; the problem lies in the legacy of the so-called Chomskyan revolution. This saw the end of language analysis as being the creation of a "logical form" corresponding to the text being analyzed. Yet those of us working in computational linguistics found this "logical form" to be useless. In fact, whether expressed in lambda calculus, Montague grammar, or whatever, it needed to be transformed into a more elliptical and referential form, which in turn needed further such transformation, and so *ad infinitum*.

By contrast, QFT, as applied by Stapp, gets us to external "stuff" (Stapp, 119):

> "The solution offered by quantum theory is expressed…in John Wheeler's likening of the quantum process of measurement to the game of 20 questions."

In this scenario, the observer asks a sequence of questions of nature, formalizable along the lines of "is the pointer between x and x+n?" Nature's reply is "yes" for the first 19 questions, occasioning a change in the density matrix corresponding to the wave function of the universe. At the 20th, it is "no" and "nature's choice", as Dirac expressed it, causes state-vector reduction.

Perhaps this is a better paradigm for language analysis? Indeed, as Wittgenstein pointed out (O Nualláin, 2003) there are deep problems with any attempt to map language onto something more referential. His solution, that of language-games, perhaps does not go far enough. Might it be better to think of the individual as using a language apparatus capable of conveying meanings related to his entire experience of the cosmos, corresponding to the full density matrix in the Stapp/Wheeler scenario, meanings that we sample down by "20 questions" to a single Piagetian scheme (ibid.) corresponding to our physical experience of the world?

So, for a "pipeline" model involving syntax, semantics, etc. we substitute analysis to determine context followed by interpretation, where only the latter includes our physical intuitions. The raw Tomonaga/Schwinger scenario envisaged by Stapp is initially shocking because it begins and ends with analysis, interrupted only by an apparently whimsical choice on the part of nature; at no point do we call on our physical experience of the world. To use a term falling into disuse, it is an absurdist scenario.

So, of course, are Samuel Beckett's and Harold Pinter's plays. Yet "Waiting for Godot" has been performed in war zones from Sarajevo to South Africa, with audiences risking death to attend. In our secular age, this seems peculiar indeed. Is

there an element of invocation/incantation, old-fashioned ritual as Beckett issued minutely detailed stage directions about "Godot's" performance?

Shirley (2004, 36) puts it so:

> "Think of the plays of Samuel Beckett. In his unnerving, austere productions, people walk about in 'purgatorial loops', repeating nightmarish scenarios, seeming caught up in entrapping states of mid…again and again he poignantly expressed man's condition; trapped, mechanical, struggling to emerge from a purgatory he doesn't understand."

If a yes/no question can change the state of the wave function of the cosmos, can the presence of an audience at an absurdist event wreak changes on all present? If the attested illnesses caused by voodoo curses are the result of action at a distance, can the scenario suggested by Stapp (2017, 119) be similar?

> "Tomonaga-/Schwinger…allows all the empirical predictions of Einstein's relativity to me maintained in spite of underlying spooky actions-at-a-distance as a result of measurement."

The notion of a "determinative" mode in the classical world is the most radical and controversial suggestion of this paper. Wishing somebody healthy does not normally work; conversely, the CIA's men who stared at goats have not been deployed in real wars as a substitute for drone strikes or the weapon du jour! There is one incident that smacks of determinativeness, the so-called Monty hall problem, described inter alia in Schechter (2000, 108-109);

> "Monty allows you to choose from one of three doors. Behind one door is a fabulous prize…behind the other two doors are joke prizes…. before Monty opens the door you choose, he opens another door and reveals a goat…what do you do?"

The conventional response is enunciated thus (ibid.):

> "If one door is shown to be a loser, that information changes the probability of either remaining choice…to ½."

Paul Erdös, one of the greatest mathematicians of all time, vociferously agreed (ibid.):

> "You are not telling me why to switch! What is the matter with you?"

Schechter explains (ibid.):

> "Your probability of initially having chosen the correct door was one in three. That probability never changes, even after Monty shows you the goat…the probability that it is behind the other door must be 2 in 3."

In the terms used here, your initial choice had a determinative effect, "jinxing" that

door so its probability was stuck at 1 in 3. Had there been 100 doors, its probability would have been 1 in 100 and the 98 goats shown would indicate a probability of 99 in 100 favouring a switch.

But wait! Neither Erdös nor the other outraged mathematicians were unaware of "statistical independence" (ibid). What obtains here seems more like a causal effect through a cloud of unknowing affecting matters in the past. In short, it is exactly what we predicate of QM observation, but now brought into the classical world.

We now need to look for mechanisms. Control theory may give us an entrée into a world in which an initially disincarnate observer, playing a game of 20 questions with nature, might cause physiological mechanisms to change.

## CONTROL THEORY AND DIFFERENT "BIOLOGIES"

While biology has proven refractory to attempts to reduce it by genetic determinism, the concept of hierarchy has yet to take hold. It would seem that the most advanced thinking on the subject was by the late Richard Strohman, who proposed two different takes as described in this collection:

> "One reparsed with the key being intracellular versus intercellular levels; the former was discerned as having an architecture of protein networks and gene-related circuits, dynamics of control theory and epigenesis, and products of bacterial phenotypes, distributed metabolic control and function. The latter had posited an architecture of tissues, neural networks and trajectories; dynamics of chaoplexity; and a product of growth regulation, learning and complex diseases.
>
> A second document took as primary the genetic, epigenetic/genetic, morphogenetic/epigenetic and organismal/morphogenetic levels. Sample agents and rules for each level are, respectively, DNA sequences and base pairing; gene/protein networks and as yet unknown enzyme function; morphogenetic fields through unknown rules; and the organism qua morphogenetic field, perhaps to be unpacked later …."

We have fields and their products at each level. We cannot reduce the organism qua morphogenetic field to the cell level as symmetry breaking distorts it.

Control theory deals with the behavior of dynamical systems with external inputs, and how their behavior can be modified by feedback. In his seminal work, Richard Strohman indeed stated that intracellular levels could be described by control theory; however, he did not provide any rule to integrate the different "biologies" as you go from lower to higher levels (or vice versa).

Indeed, there are other theories that we could use to describe our system.

While control theory deals with external control parameters, the interdisciplinary

field of Synergetics deals with both external and internal control parameters. In other words, in synergetics, the system of interest is subject to control parameters which may be fixed from the outside or may be generated by part of the system considered. Thus, in some sense, control theory is a sub-field of synergetics, only dealing with external inputs. Originally, as we were mainly concerned with the integration of different "biologies" with external control, and with mind/observer states being a significant input, we adopted the control theory formalism. However, looking more in-depth at each biology, we should describe the within biologies using the synergetics formalism. For the sake of simplicity, we will remain in the control theory framework.

In summary, we argue that control theory may provide a framework to accommodate different conceptions of levels necessary in biology, with the brain as the organ of interest consisting of different biologies, and our minds playing a crucial role as inputs into the system.

In control theory, we need to define the model architecture and describe the sub-systems and control parameters that govern the dynamics of the whole system. To do it, we usually plot a diagram known as the block diagram. Within this formalism, we typically have a controller and a process which is controlled. We often denote the controller with a letter ***C*** and the system to be controlled with a letter ***P*** (the convention for the so-called 'plant'). Also, we have inputs and outputs.

As convolution in the time domain equals multiplication in the frequency domain; we tend to model systems in the frequency domain. Classical control theory uses the Laplace transform, a method to change differential equations in the time domain into a regular algebraic polynomial in the transform domain. Once we have modelled the dynamics of a given system with differential equations and converted it into the transform domain, it can be manipulated with greater ease. In the frequency domain, ***C(s)*** and ***P(s)*** are the Laplace transforms of the controller ***C*** and process ***P***, respectively.

Another essential entity in control theory is the transfer function. In the block diagram, the transfer function, often known as the system function, is a mathematical expression of the relation between the input and output based on the Laplace transforms describing the whole system. We often denote the transfer function as ***TF(s)***.

For the sake of simplicity, we begin to describe two fundamental "biologies" within the brain using control theory, but we could extend this approach to model different "biologies." First, we describe the "biology" of water, as water represents the only and the essential environment in which the processes of life can take place. We, in particular, model the physics of the ***water dipoles***, which follow the quantum principles, and hypothesize that this "biology" acts as the controller of the whole

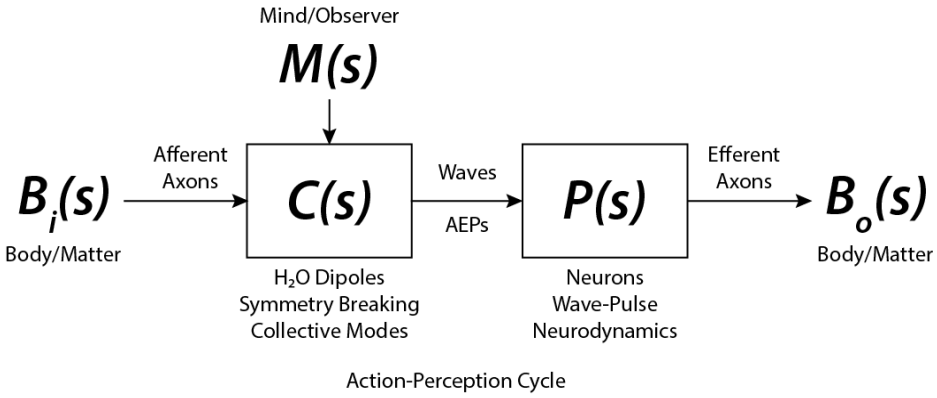
system, our brains. We, thus, denote the "biology" of water with a ***C(s)***. Second, we depict the "biology" of neurons, as neurons are the core components of our brains. We, in particular, are more prone to model ***populations of neurons*** rather than single neuron activity. In any case, neurons are classical objects, therefore, following classical principles, and hypothesize that this "biology" is, in fact, the process to be controlled. So, we denote the "biology" of populations of neurons with a ***P(s)***.

Finally, we denote body/matter input and output activities with $B_i$ and $B_o$, respectively, and the mind/observer states with an ***M***; $B_i(s)$, $B_o(s)$, and ***M(s)*** being their respective Laplace transforms.

As mentioned, in control theory, we usually start by describing our mathematical modeling with a block diagram. In this paper, we begin to adopt, very simplistically, straightforward models without and with feedback, control theory mostly being concerned with feedback systems. Also, we compare the two approaches, the without and with feedback models, with the state-of-the-art approach to model brain dynamics, an approach that we, as neuroscientists, have been using for a while. The next figures intend to illustrate our attempts to describe brain-mind dynamics utilizing the control theory formalism.

On the one hand, **Figure 1** illustrates a mathematical model without feedback. With this mathematical modelling, external inputs, both body/matter input activity $B_i(s)$ and mind/observer states ***M(s)*** enter into the system through the ***C(s)*** module. Within this module, the external inputs break the symmetry of the water dipoles. However, inputs may possibly break the sysmmetry of any other physical structure sensitive to it. For example, it has suggested by Stuart Hameroff and Roger Penrose that the "biology" of microtubules plays a crucial role in brain-mind dynamics. Symmetries are very important in physics. Traditionally, information has been associated with ordering and therefore to breakdown of symmetry. According to the Goldstone theorem, every time a symmetry gets broken, massless particles automatically appear. These particles are known as Goldstone bosons. This symmetry breaking, which in principle is external, but can also be spontaneous, generates long-range correlations. In the brain case, it may create Goldstone bosons of unneglectable mass, as the brain is confined in a finite space. They may travel over the brain and do interfere with the dendritic currents of non-local brain neurons. We refer to the readers to the plots of average evoked potentials (AEPs) showed in W.F. Freeman 1975 that motivated the late Walter Freeman to consider QFT to formalize brain processes. Thus, these waves (AEPs) are the output of the ***C(s)*** module and the input to the ***P(s)*** module. Then, as a result of this input, and now within the module ***P(s)***, the membrane potentials of these neurons change - under the influence of the Goldstone

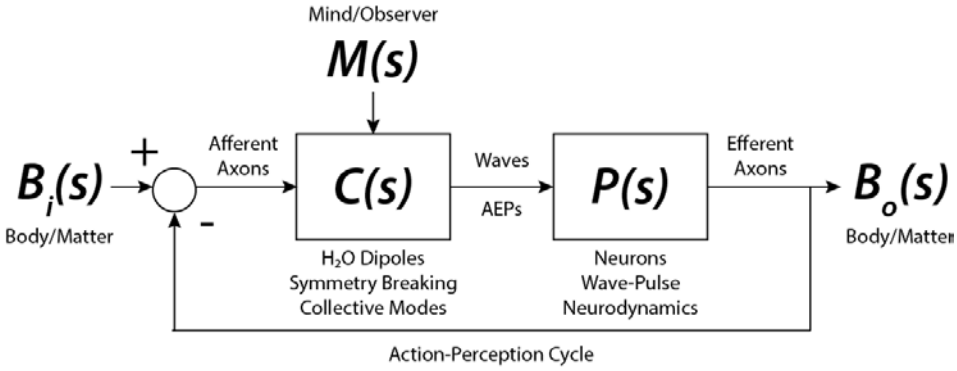
bosons - to generate action potentials that travel to other brain regions and body parts (at a different speed, generally slower). This is the output body/matter activity that we denote as $B_o(s)$.




$$TF(s) = \frac{B_o(s)}{B_i(s)} = (1 + M(s)/B_i(s))P(s)C(s)$$

**Figure 1.** A first model attempting to describe brain-mind dynamics using the control theory formalism. $C(s)$ and $P(s)$ are the Laplace transforms of the controller $C$ and process $P$, respectively. $B_i(s)$ and $B_o(s)$ are the Laplace transforms of the body/matter input and output activities, respectively. $M(s)$ are the mind/observer states. Finally, $(1+M(s)/ B_i(s))P(s)C(s)$ is the transfer function of the system.

On the other hand, **Figure 2** illustrates a model with feedback. This mathematical modelling with feedback will work exactly like a model without, but also, the action potentials, in other words, the signal outputs going to the body/matter $B_o(s)$, will feedback to the system as inputs generating symmetry breaking further.



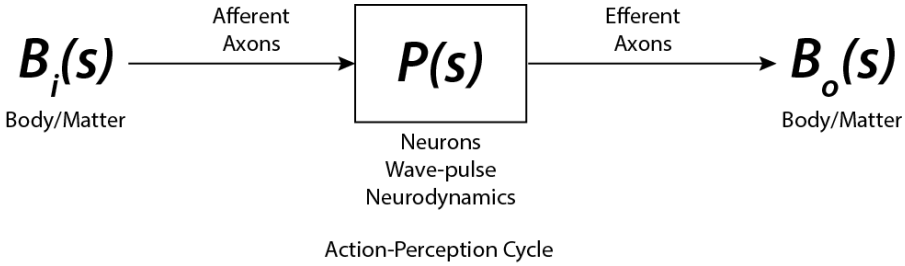

$$TF(s) = \frac{B_o(s)}{B_i(s)} = \frac{(1 + M(s)/B_i(s))P(s)C(s)}{1 + P(s)C(s)}$$

**Figure 2.** A second - and more generalizable model - attempting to describe brain-mind dynamics using control theory. ***C(s)*** and ***P(s)*** are the Laplace transforms of the controller ***C*** and process ***P***, respectively. $B_i(s)$ and $B_o(s)$ are the Laplace transforms of body/matter input and output activities, respectively. ***M(s)*** are the mind/observer states. Finally, $((1+M(s)/B_i(s))P(s)C(s))/(1+P(s)C(s))$ is the transfer function of the system.

In our brain, we may have both types of models, and they could be stimuli and circuit dependent. Some situations that require a fast response but little processing may be implemented in circuits without feedback (or apparently without feedback), while conditions that need stable responses and more processing, e.g., the fine tuning of motor responses in the cerebellum, may be encoded in circuits with feedback. Interestingly, feedback models are a generalization of the former models, so from now on, we will only be interested in describing models with feedback, and therefore, control theory as the mathematical framework.

However, we neuroscientists often take three approximations to relax the complexity of the problem. The final model carrying over the approximations is illustrated in **Figure 3**. First of all, we bypass the control function assuming that ***C(s)*** is equal to ***1***. In other words, we are not interested in other "biologies," and even less in "biologies" of a different kind or following non-classical principles such as QFT. Second, we neglect the feedback. We usually assume a deterministic input, which encodes for the experimental condition, for example, an optogenetic manipulation. Moreover, very few times we assume a stochastic input, by adding neuronal

fluctuations. But essentially, we do not assume that the output affects the input. Third, we discard mind "stuff." We assume that mind is the product of brain activity and not an actual input. By doing this, we end up studying the brain as a black box system described with the most straightforward transfer function: ***P(s)***.




$$TF(s) = \frac{B_o(s)}{B_i(s)} = P(s)$$

**Figure 3.** A state-of-the-art model describing brain dynamics. ***P(s)*** is the Laplace transform of the process ***P***. $B_i(s)$ and $B_o(s)$ are the Laplace transforms of the body/matter input and output activities, respectively. Finally, and for this particular case, ***P(s)*** is also the transfer function of the system.

We neuroscientists usually think, investigate, and further develop models of brain dynamics enhancing the neuron doctrine by describing process ***P(s)*** in greater detail. And we can describe it in human subjects (Bernal-Casas et al., 2015), but also in animal studies (Bernal-Casas et al., 2017). In doing so, we depict process ***P(s)*** as a hierarchy of several systems within the same "biology", as Freeman did with his variety of sets, including excitatory and inhibitory populations of neurons. But we do not take into account other hierarchies or "biologies." Hierarchies that live directly above or below, and exchange order parameters. Nevertheless, the biology of water matters! As mind does affect matter!

Interestingly, all of these models may be Popper-falsifiable, including our novel two attempts, without and with feedback models, to describe brain-mind dynamics using the control theory formalism. In simple words, we can run a model comparison among the three models: **Figures 1, 2**, and **3**, to select the optimal model to explain the

collected data. In other words, we can compare their respective transfer functions ***TF***(s). The model with the highest evidence, the model with the highest accuracy and the lowest complexity, will be the most likely model to account for the observations. **If we have been correct for the last decades, the model of Figure 3 should excel over the models of Figures 1 and 2.** However, What if this result does not hold? What if the models of **Figures 1** or **2** have the highest evidence? Would that open the door to study and include the "biology" of water and mind/observer states in our state-of-the-art modeling approaches?

In mathematical terms, if the "biology" of water plays a major role in the dynamics of the system, as we believe it does, adding complexity to the transfer functions ***TF(s)*** of the models of **Figures 1** and **2** by including the term ***C(s)*** will be counterbalanced by having a better accuracy in describing the system's behavior. Likewise, if our minds are external inputs to the brain, as we believe it happens, the quotient term $\boldsymbol{M(s)/B_i(s)}$ that appears in the transfer functions ***TF(s)*** of the models of **Figures 1** and **2** will be unneglectable, and hypothetically time-dependent.

So, with this new formalism of downwards-causation, the most directly challenged would be mainstream neuroscientists, who cling to the belief that, in spite of the claims of orthodox QM, consciousness is a product of brain activity, rather than an essentially mental input into brain activity. However, besides mainstream neuroscientists, there is a large community of other scientists who likewise believe that our "minds" are products, or by-products, of brain activity, rather than sources of essentially mental inputs into the unfolding of the mathematically-physically described different "biologies" of our brains. These are the scientist of "materialist" or "physicalist" persuasion, who probably constitute the majority of the scientists who hold definite opinions on this matter.

As a final remark, it will be clear to the reader that this is the combination of work that has been going on for almost a decade on the one hand and on the other it is the beginning of a much more precise exemplification of the principles that we have arrived at on the other.

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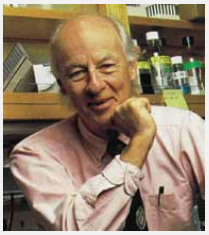
# Appendix

## Molecular genetics (*information*) and dynamics (*energy*) are irreducibly complementary: *The information-energy complementarity (IEC) postulate of Strohman**

*(R. Strohman, 1927-2009, previously unpublished)*



| | Agents | Architecture/ Organization | Dynamics (Rules of integration) | Emergent features |
|---|---|---|---|---|
| Intramole-cular level | DNA, proteins, small molecules, environmental signals | Protein networks<br>Chemotaxis, metabolic pathways<br><br>Gene related circuits<br>Epistasis, pleiotropy, transcriptional control<br><br>DNA repair enzymes<br>DNA & chromatin marking<br><br>Other functional protein groupings to be discovered | Control theory<br>Thermodynamics/kinetics<br><br>Epigenetic<br>Rules unknown | Robust phenotypes in bacteria.<br>Distributed control in metabolism<br><br>Functional integration<br>Adaptive behaviors<br><br>Sequence conservation<br>Patterns of gene expression |
| Intermole-cular level | Cells, Extracellular Matrix, hormones, small molecules | Cell networks<br>Neural networks<br>Tissues<br>Morphogenetic pathways<br>"trajectories" | Chaos, scaling, fractals<br>Attractor states | Differentiation<br>Learning<br>Growth regulation<br>Fractal physiology<br>Complexes diseases |

*The IEC concept was independently formulated by S. Ji in 1991 [1] and further developed in [2, 3]. The wave packets in biopolymers carrying both energy and information to drive goal-directed molecular motions are referred to as the *conformon* (https://en.wikipedia.org/wiki/Conformon).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[**3**] Ji, S. (2018). The Cell Language Theory: Connecting Mind and Matter. World Scientific Publishing, New Jersey. Pp. 33-34.