How Intelligence Evolved?

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Abstract

A definition of intelligence in terms of the computational principles by which a sentient being may make sense of a universe structured according to the nilpotent universal computational rewrite system (NUCRS), with an infinite universal alphabet as discovered by Rowlands and Diaz, is briefly set out. This alphabet defines the semantics of quantum mechanics in terms of a universal grammar, such that the nilpotent generalization of Dirac's quantum mechanical equation is the computational machine order code. Investigations underway show that this discovery not only provides a fundamental semantic foundation for universal quantum computation, but is the likely keystone of a fundamental computational foundation for mathematics, quantum physics, the genetic code / molecular biology, neuroscience and an evolutionary cosmology. The NUCRS is a universal organizational principle, which provides well determined testable models, some already in agreement with experiment. These show that the structure of the cosmos, the genetic code, the human brain, and human language, correspond to quantum mechanics, as determined by the generalized nilpotent Dirac equation D(N) and the complementary semantic theory of quantum holographic pattern recognition specified by the 3 dimensional nilpotent Heisenberg Lie Group. The two nilpotent representations correspond to the required division of the universal nilpotent quantum mechanical state space (NQM) into its Clifford / fermionic and Lie / bosonic parts, where the 3D Heisenberg Lie algebra defines NQM Heisenberg uncertainty and, remarkably, a dual so that under the right circumstances this duality is the means by which to compute holographically, as, for example, in magnetic resonance imaging machines (MRI). We postulate that the NUCRS's power to be able connect to such significant ideas as nonstandard analysis over the surreal numbers fields, Wheeler's meaning circuit, the cosmological holographic principle, quantum holography, anticipatory computation and quantum thermodynamic machines, shows it to be an Evolutionary 'Anthropic' Semantic Computational Principle, by means of which a sentient being is able to comprehend the rules by which Nature is apparently structured.

A semantic model of computation

Success in science is measured by agreement between the predictions of the particular mathematical language description used and experiment, and the language's interdisciplinary breadth. Syntactic correctness of the language is thus a necessary but not necessarily sufficient condition. It may only guarantee a combinatorial explosion of possible correct solutions, as now, for example, appears to be the case in string theory according to the admission of one of its originators, Leonard Susskind (Susskind, 2005). It supports Peter Woit's argument that string theory is, in Pauli's famous phrase, 'not even wrong' (Woit, 2006), because correct syntax is not accompanied by correct semantics, as in a semantic language model of computation, such as the rewrite systems synonymous with computing / information processing, which specify a grammar as well as a syntax appropriate to the problem needing solution. Thus, the theory of nilpotent quantum mechanics outlined below, may be able, we hypothesize, to give physicists their much sought after 'Theory of Everything' in the form of this NUCRS foundational universal organization principle.

Rewrite systems concern the languages in which programs are rewritten as symbols *for computing hardware to interpret*. The NUCRS (Rowlands and Diaz, 2002, Diaz and Rowlands, 2005) is of particular significance, since its subset alphabets emerge in a minimal way and not only have a mathematical interpretation as algebra, but concern the nilpotent Dirac algebra, with which one can generalize Dirac's well known quantum mechanical equation, so as include not only mass and electric charge, but also the strong and weak charges, and, implicitly, the property of spin (Rowlands, 2004, 2005, 2006)..

The NUCRS has a universal grammar in the sense that it delivers the entire infinite alphabet of symbols in one step, when presented with zero, in a simplified presentation, as the initial subset alphabet. (In a more technical extended presentation the need to start with anything at all can be dispensed with.) This universal system, we conjecture, has a minimum of two rewrite rules or productions (which it turns out are dual):

i) a creation operation, delivering a new symbol at each invocation, where this new symbol may be a single

character of the alphabet, a subset alphabet, or the entire alphabet, and

ii) a conserve / proofreading operation, which examines all currently existing symbols to ensure that the bringing into existence of a new symbol or subset alphabet, etc., produces no anomalies.

The NUCRS differs from traditional rewrite systems, of computational semantic language description with a fixed or finite alphabet, in that the rewrite rules allow new symbols to be added to the initial alphabet. As already stated, we start with just one symbol representing 'nothing' and two fundamental rules: *create*, a process which adds new symbols, and *conserve*, a process that examines the effect of any new symbol on those that currently exist, to ensure 'a zero sum' again. In this way at each step a new sub-alphabet of an infinite universal alphabet is created. However the system may also be implemented in an iterative way, so that a sequence of mathematical properties is required of the emerging sub-alphabets; and we have shown that one such sequential iterative path proceeds from nothing (as specified by the mathematical condition nilpotent) through conjugation, complexification, and dimensionalization to a stage in which no fundamentally new symbol is needed. At this point the alphabet is algebraically congruent with the nilpotent generalization of Dirac's famous quantum mechanical equation, showing that this equation defines the quantum mechanical 'machine order code' for all further (universal) computation corresponding to the infinite universal alphabet.

The property of the universal nilpotent rewrite system that a new symbol can stand for itself, a sub-alphabet or the infinite universal alphabet, allows NUCRS to rewrite itself, so as to enable it to describe the ontological structure at a higher (hierarchical) level in terms of those at lower levels, beginning with the fundamental level. This rewrite system with its nilpotent bootstrap methodology from 'nothing / its empty state' thus defines the requirement for universal quantum computation to constitute a semantic model of computation with a universal grammar. It is also significant that, though the universal rewrite system generates both number systems and algebras, it is not confined to these systems, and does not depend on the pre-existence of numerical or algebraic concepts, or any of the ideas of set theory, and the zero is not confined to being that of the empty set. The mathematical structure generated derives rationals from reals, not reals from rationals; and shows that complexification logically precedes discrete numbering, a result that cannot be derived from any form of set theory (Rowlands and Diaz, 2002, Diaz and Rowlands, 2005).

Such a nilpotent computational rewrite system describing both arithmetic and geometric properties must describe what is called universal computer construction, i.e. such nilpotent quantum computation will be both computer universal in the sense of arithmetic and constructor universal in the sense of geometry. That is, it includes both universal digital computation as discovered by Turing (Turing, 1936) in the form of the universal Turing Machine model, and universal computer construction or self replication as revealed by Von Neumann (Von Neumann, 1966).

Scientific perspectives on semantic computation

From the above it would appear that:

i) both theoretical physics and mathematics, grounded in nilpotent quantum physical process action, are single, possibly equivalent, bodies of human linguistic / semiotic knowledge emergent from the human brain, a quantum physical semantic machine, as the evolutionary result of the semantic natural physical law NUCRS describes; and

ii) that, as proposed by Langlands, mathematics is indeed (in this new computational NUCRS foundation) a single inseparable body of knowledge, where theoretical physics will be the same thing as mathematics, thus explaining what is often referred to as 'the unreasonable effectiveness of mathematics in relation to physics' (Chapline, 1999).

That is, the NUCRS describes the basis for two new foundational disciplines, the computational foundations of physics and mathematics. Thus, this law's semantic mathematical language description would be expected, in addition to correct syntax, to provide the description of such properties as:

i) a measure, metric and Hamiltonian / Lagrangian for each variable, process and system respectively described (examples, Fatmi and Resconi, 1988; Schempp, 1992); and

ii) thermodynamic principles in relation to quantum measurement, where information becomes a physical resource such as entropy production, as occurs in magnetic resonance imaging (MRI) machines, where the real and virtual imagery of 3 + 1 relativistic space-time physical structures, exist independently of the presence of any observer. This is the fact that natural radiation of any kind, incident on any object it illuminates, shows to be the case; for, as is known and can be demonstrated holographically, any such incidence will, quite independently of any observer, effect local changes of the radiation's amplitude and phase, so as to capture the 3 + 1 relativistic space-time image of the illuminated object as appropriate to the nature of the incident radiation.

All the evidence, we have so far, supports the hypothesis that nilpotent quantum mechanical language description, NUCRS, constitutes 'Nature's rules' in accordance with the Premise and Mission Statement of the British Computer Society's Cybernetics Machine Group, that 'In science, Nature sets the rules, but it must never be

forgotten, that it is only because life has exploited these rules successfully for billions of years to our evolutionary advantage, that human brains are able to understand them. The mission, at the physical foundations of computing / information processing if one accepts the premise, is therefore to identify how these rules were exploited, by the intelligence of the human brain, to achieve this end.' (http://www.bcs.org.uk/cybergroup.htm) That is to say, the NUCRS turns this premise into an **Evolutionary Anthropic Semantic Principle.** Life, intelligence and mind are thus postulated to be a natural consequence of the proposed cosmology and, as Paul Davies puts it, not just flukey optional extras (Davies, 2006).

The evidence outlined below, that the NUCRS can indeed be identified with the principal stages needed to accomplish this mission, as set out in its premise, strongly advances the claim that the NUCRS generalization of the computational rewrite concept can be taken as a new fundamental computational foundation for both quantum mechanical and mathematical language description, so as to constitute, we would propose, from these stages, a likely basis for a 'Theory of Everything' in the form of the universal fundamental organizational principle, NUCRS.

The evidence is, firstly, that the DNA / RNA genetic code, exemplifying life, fits the essential criteria necessary for it to be a nilpotent rewrite system, so as to define a further progression of the NUCRS infinite alphabet. That is, the genetic code is a semantic code, which specifies the ontological geometric structures of living systems (Marcer and Schempp, 1986, Gariaev et al., 2001, 2002) – including those of all molecular biology (and hence of the human brain) – grounded upon the predicted NUCRS fundamental level structure of full Standard Model elementary particle physics, within $3 + 1$ relativistic space-time, both of which simultaneously emerge from their empty set, as D(N) shows, by spontaneous symmetry breaking (Rowlands, 2004, 2005, 2006).

Secondly the evidence of the human brain's natural semantic language abilities, exemplifying the *modus operandi* for the advancement of human understanding, i.e. intelligence, points strongly to the fact that the brain's molecular neural and gial structures correspond ontologically to a yet further progression of the infinite alphabet realized within the DNA / RNA genetic code itself, so as to permit the human brain by means of NUCRS rewrite mechanisms to input / output natural language, i.e. to hear and to speak, and to process language semantically, i.e. to proofread it / think. And thus the reasons, for the semiotic, sequential nature of all these processes, for which the evidence is natural language's ability to take the form of the written word, and the speed by means of which the human brain is able to carry out all these thought processes, is furnished with an explanation, as is the human brain's stream of conscious perception. For all are

grounded, in NUCRS behaviour as sequential single parameter thermodynamic quantum mechanical Carnot engine (QCE) action (Scully et al., 2003), which may be hot running, invalidating the 'often invoked' argument that brains cannot operate as quantum systems.

The evidence that the processes of semantic computation described are fundamentally quantum physical in nature, is an accepted conclusion about the nature of universal computation already reached independently by Deutsch and Feynman (Deutsch, 1985, Feynman, 1986). Thus, digital computation, which Deutsch has shown quantum computation includes, would constitute a universal regime of rules for syntactical but not yet semantically correct computation, so as to explain why the required semantic basis for any digital computation / algorithm must in general be effected through the agency of the human brain. (Nilpotent computational system may loosely be thought of as computation using zero (i.e. topological computation) rather than bits in the binary system 0, 1 and it is more general than binary computation as Deutsch shows.) This raises the question 'Could semantic rather than digital computation be what we mean when we refer to the sentient human brain as having 'commonsense'?' (Marcer, 1986) For, from the known facts of its working, in particular its human language capabilities, the human brain is almost certainly a universal semantic computational machine. The NUCRS thus marks a clear distinction between human and artificial intelligence (where the Turing test is now a necessary but not sufficient condition), and would explain why the architecture of the human brain is so different from its digital counterpart, and the way in which a conscious sentient being is different from a zombie.

There are also other senses in which digital computation is incomplete. For, if described simply in terms of universal logical primitive NAND, it lacks, as Feynman points out (Feynman, 1986), the additional 'physical' primitives, such as the unit wire and signal exchange, that the descriptions of digital computation require if they are to be physically implemented and executed (as rewrite systems implicitly require); an example is Clement, Coveney, Jessel and Marcer (1999), where the argument depends on such physical primitives. In addition, descriptions of digital algorithms can have no meaning unless, as Wheeler has pointed out (Wheeler, 1986), there exists some actual physical means by which they can be carried out / executed. Semantic computation, in fact, explains why, despite a digital computer's simplicity, there are no naturally evolved species with nervous systems based on digital architectures. This preference of nature can be attributed to the fact that physical trajectories / systems are known to naturally follow geodesics and principles like that of least action (as indeed does quantum mechanics in Feynman's sum over histories formulation)

(Feynman and Hibbs, 1965), and so will most likely lead to any natural computation / measurement taking place in a minimum number of computational steps, that is, optimally (Clement, Coveney and Marcer, 1993; Dahleh, Pierce, and Rabitz, 1990).

The requirement, cited by Deutsch, that all valid computation must be canonically labeled (Deutsch, 1985), is satisfied in nilpotent quantum mechanics (NQM) as governed by the nilpotent Dirac equation (D(N)), because the Pauli exclusion principle applies to NQM's fermionic states, so as to be in agreement with Wittgenstein's (semantic) principle (Wittgenstein, 1975), that there is necessarily only one proposition for each fact that answers to it, and that the sense of a proposition cannot be expressed except by repeating it. The NUCRS shows that, contrary to the Platonic assumption, mathematical language description is just another form of natural semantic language capability, which derives its origin from the semantic computational capabilities of NQM. For natural languages have only now made their evolutionary appearance, partly because they necessitate a nervous system and biological brain of the size, power and complexity the human brain, which the facts show has never existed until the present era; and also because of the enhanced evolutionary advantage that semiotic / semantic language communication and understanding of the world including mathematics now demonstrably offers for the survival of the human species, at the present stage of evolution; and where in the foundation of any natural language, a necessary grammar for semantics in addition to syntax, provides what is known in human communication as its 'commonsense'. For the objective of mathematical language is surely to demonstrate that the human brain's 'commonsense' semantically arrived conclusions, do indeed follow syntactically from their respective premises.

Brains as quantum Carnot engines (QCEs)

Canonical labeling also supports the explanation of the conscious sentient human brain as functioning as a QCE at the semantic ontological NUCRS level of biological neural structure (Fatmi and Resconi, 1988, Hoffman, 1989, Fatmi et al., 1990). Human thought can thus be inferred to be quantum measurement, i.e. a computational input / quantum preparation followed by computational output, so that it is able to function semiotically as a neural computational rewrite system, as is evidenced by its natural semantic language capabilities. So, in the mathematical language of category theory, the arrows of the theory can be quite literally taken as formally representing 'such arrows of human thought' (Schempp, 1986, 1992; 1993, Marcer and Schempp, 1997, 1998, 1998,

Marcer and Mitchell, 2001, Schempp, 1986). And for example, where in relation to the quantum holographic pattern recognition information processing in terms of the 3D Heisenberg Lie group, the Frobenius-Schur-Godement identity, below, describes (though holographic phase transforms H_ν frequency ν) the adaptive resonantly coupled frequency / phase (ν,θ) memory organization of four wavelet mixing of the quantum wave amplitudes ψ,φ, ψ',φ', so as to produce a 'hologram' spectrum which constitutes the 'pages' of an associative read / write filter bank memory, and where as the identity shows there is little or no cross talk between the pages.

$$<H_\nu(\psi, \varphi;.,.)| \ H_{\nu'}(\varphi',\psi';.,..)> = <\psi\otimes\varphi|\psi'\otimes\varphi'> (\nu = \nu' \neq 0)$$
$$= 0 \qquad (0 \neq \nu \neq \nu' \neq 0)$$

This (ν,θ) organized memory of very narrow frequency spectral windows / pages, is able to contain holograms situated on hologram planes. These thus constitute a mathematical chart of hologram planes appropriate to cerebral cortical storage organization, where the generalized holograms of its input holographic sensory experience and thought correspond to the left hemisphere, their semiotic canonical labeling, the right hemisphere and the signal pathways / mappings between these, the corpus callosum. Support for this comes, from the AndCorporation (Sutherland, 1999), where 3D holographic face recognition software based on quantum mechanical phase models, i.e. 'phase gates', has been realized on conventional digital machines, so as to demonstrate that such phase-based face recognition does work and has significant advantages over non-quantum mechanical designs, even though the purely quantum mechanical aspects of such computations cannot be realized. It can therefore be postulated, as is also argued here in general for living systems, that such features of the human brain as the mind and consciousness each result from a new state of matter called a phaseonium (Scully et al., 2003), which retains a small amount of quantum coherence phase θ, appropriate to the quantum brain's QCE action, absent in its classical thermodynamic CE counterpart. That is, the brain's structure constitutes, like the proposed models of the universe and DNA, a QCE with new states of matter, its qualia, able to employ quantum holographic pattern recognition to perceive the structure of the universe (on a particular scale) in terms of 3 + 1 space-time holographic image, as first conceived by Pribram (Pribram, 1991).

This indicates, that Dirac's bra / ket quantum mechanical formalism in NQM constitutes a universal rewrite system, where bra and ket serve as the two creation and conserve rules / productions. In other words, in the case of bosons, it describes a Bargmann Fock quantum-field-theory of creation and annihilation operators, where, in agreement with Perus and Bishofs (2003), in the basic general

equation $|\Psi\rangle = |\Psi\rangle\langle\Psi|\Psi\rangle$, the rightmost $|\Psi\rangle$ may represent a holographic output following from the leftmost $|\Psi\rangle$ a holographic input, such that $|\Psi\rangle\langle\Psi|$, or in expanded form

$|\Psi\rangle\langle\Psi|\Psi\rangle\langle\Psi|\Psi\rangle\langle\Psi|\Psi\rangle\langle\Psi|\Psi\rangle\langle\Psi|\Psi\rangle\langle\Psi|\Psi\rangle\langle\Psi|\Psi\rangle\langle\Psi|$,
represents the action of a 'paged' (v,θ) organized associative read / write memory and filter bank as already described above. Thus quantum holographic procedures may, in direct correspondence with their classical (but degenerate state) counterparts, be described in terms of actual quantum wavefunctions. For example, as shown by Schempp in the case of MRI imaging systems (see http://www.bcs.org.uk/cybergroup.htm sidebar quantum holography), such MRI quantum holographic outputs constitute actual diffraction patterns, which do indeed exhibit the holographic behaviour predicted.

This leads to the inference, that the brain is an almost perfectly dynamical balanced QCE that controls our thought processes between its neural workings and the corresponding working of the mind (as possibly governed by a 'gial / microtubule' control field of energy determining the brain's mental arrows of thought) (Nobili, 1985, 1987; Penrose, 1990, 1998; Tuszynski and Brown, 1998). It is therefore a balance, that can be changed at will as we each learn in early childhood, via the application of a suitable source of energy to this field (the will) so as to produce the required mind-brain interactions in response to, say, data arriving at the senses or as retained in memory. And such a whole sentient brain-mind working as a single heat bath QCE governed by the single phase parameter θ, would explain why consciousness functions as a 'stream', i.e. serially.

Furthermore, the two hemispheres organization of such a brain shows how these corpus callosum mappings, from a unique name or symbol to each stored phase conjugate object image, are able to assign meaning in relation to human language. And this must be the true power of the human brain that it is able to process words not just syntactically but also by their corresponding charted semantics, as known from sentient human being's actual memory of sensory geometric / holographic experience. For although such experience will be subjective in the sense, that it takes place from the reference frame and viewpoint of each individual brain, there remains (through the quantum holographic phase conjugate object imagery of the each differently viewing observer) a common channel of objective communication, the 3-D objects of the real world themselves. For it (the channel) serves to provide the required canonically labeling, necessary to the computation since no two 3D objects (and hence their two corresponding coincident phase conjugate object images) may occupy the same 3D spatial position at the same time. Each sentient observer may thus reach out to touch, or to see, hear, or smell the object in question, to determine the truth about it as stated by another; or may conduct an agreed experimental determination of its properties using scientific instrumentation, the process known as science.

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