Negentropy indicative of Consciousness: a Law of Nature; Link between Consciousness, Randomness and Sparse Distributed Networks

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Abstract

Maharishi Mahesh Yogi posited the concept of 'The Source of Thought'. In Vedic science (Shiksha), the concept may be equated with Para when describing the four levels of thought. Para is transcendental to the space of ideas. It is the state of mind in "transcendence" (deep meditation) i.e. empty of ideas. Yet the word Para also means supreme, which refers to that state also being the *source* of all possible ideas. From a Mathematical and Computer Science perspective, the only equivalent candidate for such a source is a true Pseudo-Random Number Generator, with the caveat that it should have a seed of infinite-length and no periodicity.

Maharishi also stated that "new ideas" in knowledge must be "discovered" simultaneously, citing Legendre's theorem "A subgroup subdivides a group", a statement which directly implies that knowledge forms the overall set. Indirect implications are that: Conscious beings form a set, and that 'God' is the largest member. However, it is not immediately obvious how Legendre's theorem applies to knowledge, until Sparse Distributed Memory emerges from Consciousness, Hankey's Complexity Biology critical instability theory is applied, and the properties of a Banach space applied recursively (fractally).

This paper also explores the difference between time-distributed and domain-distributed randomness as a source of creativity and thought, and their implications for simplified efficient Particle Swarm Optimisation. Randomness is seen to be just as important a part of the Definitions of Consciousness (McKenzie's Memory, Perception, Imagination and Looping). It is then sufficient to postulate as a Law of Nature: non-zero Negentropy indicates the presence of Consciousness.

Finally, we highlight the insight that properties of Sparse Distributed Memory, aka a Banach space, inherently lead to Analogy. Its use by any Consciousness entity *should* result in self-directed learning. Tononi et al were right, with the caveat that Integrated Information Theory's properties may be inherent and emergent rather than exclusively explicit.

1 Introduction

Hong and Pavlik explored how randomness can greatly increase efficiency in a Randomly-weighted Fourier Network.[1] Pitti Weidman and Quoy apply random permutations to (ordered) ordinal codes, intentionally creating *sparse representations* to great effect.[2] Fuzzy-PID Control also paradoxically increases effectiveness,[3][4][5] and Laughlin shows how fly eye networks maximise entropy through "whitening".[6] It seems that in nature, when randomness is introduced it has a counterintuitive effect. The question is *why*?

The initial exploration of Consciousness[8] did not go into enough depth on randomness. This paper explores a new perspective, inspired by Maharishi Mahesh Yogi's insights[7] into Consciousness.

In the paper on Epigenetics[9] a new Law was postulated that wherever Negentropy is present then so is Consciousness. However this may turn out to simply be a Law of Nature. Hankey relates that in discussions witnessed between Brian Josephson and Maharishi Mahesh Yogi on the Laws of Nature, Josephson stated that the Laws *must* be inviolate: Mahesh pointed out that Josephson had not fully understood. Querying further, Hankey relates that Mahesh would refer effectively to God as the source of the Laws. This moves the goalposts to requiring a Definition of God, discussed below and in the initial exploration of Consciousness.[8]

It is a well-known adage that asking the right question often encodes the answer, however when that is not forthcoming an alternative technique is to hold the question in mind (sometimes for months), and *over time* some random event, conversation, or other unrelated insight will trigger a "eureka" moment as the answer miraculously is found.

Put another way: the qualia representing the question and the qualia representing the answer had a "bit of a moment" in the time-domain where *effectively* random events (random qualia as perceived by the experiencer) connected the two together. If however the individual is, putting it colloquially, "stressed to the eyeballs" i.e distracted by other qualia, whether internal or external, then the chances of being able to recall the original question *or pay attention* to the crucial arbitrary event are clearly slim to none.

Explored below, then, inspired by Pitti et al, Hong et al and many others, is how randomness (infinite entropy) in both the complexity-domain and the time-domain can paradoxically result in *negative* entropy, asking the burning question "why?", aka "What The Hell??"

2 Randomness

If the encoding of all possible ideas is generated from a PRNG with an infinitely-long seed, the output, whilst indistinguishable from white noise and exhibiting infinite entropy, will still contain all possible ideas, each idea being encoded as a sequential stream of quale in a given qualia. A common misconception from cryptographic testing of PRNGs, easily refuted when true-random sources of entropy are tested, is the expectation that the probability of extreme-long runs of fixed patterns (all zeros for example) is much lower than reality.

It sounds a little absurd, on the basis that if the seed is infinitely long then a true PRNG would generates infinite combinations. However those infinite combinations - *not in the same order* - would already be present in an infinite seed, making the use of the PRNG effectively superfluous. However firstly the concept is an analogy and a hypothesis, secondly the value of the seed is unknown, thirdly it *might* be the case that the seed is not infinite in length after all, and fourthly evidence in the form of negative entropy throughout the universe supports the hypothesis that knowledge is being systematically "organized" despite both infinite supply and variety of that knowledge.

A useful insight from Computer Science here is that Compression Algorithms *never* succeed in compressing true-random data. In fact the file size *increases* due to structural information associated with the algorithm. Infinite entropy is simply impossible to beat. The phenomenon is sufficiently well-known that Cryptographic test suites (such as NIST STS)[10] use compression to test for randomness.

3 Akashic Records

What are the Akashic Records? Traditionally they are postulated as being the history of all that has occurred in the universe.[11] However if the universe is a loop,[12][13] then one of the key characteristics of Definitions of Consciousness is met: cyclic feedback. And it is not such a stretch of imagination to infer and surmise that the Akashic Records are not just a history store, but are implicitly *the* Memory store of a Conscious being: our universe.

Additional implications arise from combining three insights: first Hankey and Thakre's work, "Fractal physiology: the reason why"; second the success of Sparse Distributed Memory and third: Legendre's theorem. The encoding implicit in fractal physiology is recognised by any Software Engineer as recursion at work (3D Mandelbrot sets[14]). Fractal encoding can result in dramatically reduced Kolmogorov Complexity, another term for which is "increased efficiency", implying less energy is required to "carry around" any given information, resulting in reduced or even negative entropy. The Mandelbulb is a useful illustration as the underlying fractal algorithm keeps cropping up in biology, both in the human body and in cruciferous vegetables. What seems fantastically implausible to have any kind of order at all can turn out to be fractal in nature, in such a small underlying encoding that ironically the implausibility is *reversed*.

Sparse Distributed Memory[15] is highlighted by Bernie Barr's Global Workspace Theory (GWT)[16] as it was implemented in LIDA by the Cognitive Computing Research Group (CCRG)[17] and many others. It would, under the circumstances of the success of SDM, be reasonable to expect all large Consciousnesses to utilize this type of Content-Addressable Memory (CAM) technique: due to the multi-way connectivity it so happens to result in multiple distributed copies of the knowledge, which so happens to be *precisely* the condition that fulfils Legendre's theorem.

The startling implications are, therefore, that beings within the universe contribute as Legendre subgroups to the sum distributed knowledge, and are even part of that knowledge, whether they like it or not. This seems to be a very special privilege and perspective until one realizes that we live in this universe and it's not like we can move to another.

The expectation is, then, that due to the self-organising pressure of efficient resource utilisation on Consciousness beings, the Akashic Records become, under Evolutionary pressure, fractal in nature and implement a "sparse distributed lookup", being the Universe's CAM. This perspective resonates with and underpins Ervin Laszlo's fantastically intuitively innovative work,[11] again confirmed by Laughlin's observations[6], Pitti et al's "whitening" technique[2] and Hong and Pavlik's "holographic" Random Fourier contribution.[1]

4 Creativity

The key question comes down to how would randomness trigger creativity? As highlighted in previous work it comes down to "silence" (meditation) allowing innovative (random) new qualia to spontaneously occur that have no prior connection to anything else. Put another way: if a given Consciousness is focussed on a particular thought or chain of, the occurrence of new qualia or new innovative association between two seemingly-unrelated thoughts is, whilst not outside the realm of possibility, highly unlikely to occur, and complex chains even more so.

To illustrate requires investigation into Sparse Distributed Memory (SDM). The theory has an algebra associated with it, based on treating ordered qualia as "addresses" (keys in a key-value store aka a CAM). A

formal proof of the algebraic properties was carried out by the inventor of SDM.

Kademlia and SDM

Interestingly, Kademlia,[18] the DHT algorithm behind BitTorrent, likewise has a formal proof on "chaining" - the ability to traverse from nearest-neighbour nodes to the destination, selecting intermediaries by way of XOR between addresses, aka computing the Hamming distance. Even more interestingly: a study by Mateos et al into epilepsy was looking at the level of connectivity in the brain.[19] It would seem that the properties of a Kademlia network and its decades of success in Bittorrent, backed up by the decades of research into SDM and demonstrating that both biological and computing modelling follow this theory, *and* the success of the Copycat Architecture, all validate SDM.

The key is that similar qualia end up being locally clustered, or at least locally-connected. By similar, this means that the XOR of the qualia (a comparison) results in a near-match. The author of SDM notes that beyond a certain "distance" a match (link) becomes impossible.[15] In Kademlia, this is where "chains" come into play, as the properties of the network require Nodes to maintain a list of Nodes with similar addresses, inherently creating a network prioritized by Hamming distance, and, crucially, to also keep a copy of nearest-neighbour's data.

Note that probabilistically there is *no forced relationship* between any addresses in a chain of three interconnected Nodes (two edges giving two Hamming distances). In other words: the probability of which bits are the same between the first and second Node has *no bearing* on which bits are the same between the second and third Node. In essence, the Hamming distance is closely related to a Hypercube, where "bundling" occurs of multiple edges to neighbour Nodes. In fact: if all Hamming distances between Nodes were artificially limited to being precisely and exactly one, the Kademlia Network would *become* a Hypercube.

Note also that in an Internet-connected network the physical distance or the IP Address is not relevant: hence the sparse data inherently becomes world-wide distributed.

SPAM detection has also become successful by creating hashes (SDM style addresses) in such a way that similarly-worded messages, even if there are repeats, will have the same hash: the concept is known as Locality-sensitive hashing.[21] Also worth observing is the success of cosine similarity (dot product) as a tool behind Analogy in Large Language Models.[22] Again: the difference in the qualia subsets is compared ($A-B$ vs $C-D$). Also, cosine similarity comes up in SDM as a variant of Hamming distance when using arithmetic digits in addresses instead of binary.

The point is, here, to reinforce that there exists Computing algorithms to both implement SDM and to create chains that iteratively connect one disparate idea to another (reliably, unlike the game of Chinese Whispers).

However how would such an association occur (be discovered) if no such association between two semi-interrelated thoughts existed, due to the "qualia difference" being too great? This is where Meditation (quietness, resulting in spontaneous randomness) comes in.

5 Silence

From the silence - the lessening of thought that could overwhelm coherent random spontaneous firing across cortices - the expectation is that new qualia generated from random firing would in some cases also trigger a random cross-association with bare-minimalistic common ground (dual subsets) between the two qualia. In other words: if a pair of such (formerly unknowing unrelated) subsets are triggered by a randomised qualia then a "new innovation" - a new "insight" - has been "created" within the mind of the individual in the Meditative (coherent) State.

The "innovation" concept was explored in-depth by Ranjan and Gabora which they term "an associative mode of thought"[28]. Ahmad and Hawkins likewise illustrate an increase in the match area or Hamming distance, in Figure 3.[29] Likewise, Kanerva's thesis notes that the threshold (number of inputs that could trigger "firing") controls the size of the region of similar addresses to which the neuron responds.[15]

This paper postulates that in more complex cases, there is no overlap between *two* qualia due to too great an SDM Hamming distance, but that a *third* (randomised) thought (qualia) happens to have enough common qualia between *both* to create an otherwise-unknown association, aka "creative innovation".

Expansion of this concept - laying down a trail exactly as implemented in the Kademlia Network - involves Chaining, where multiple such "random" qualia interconnect in a chain between two distant ideas with too great an XOR (difference). Examples of such would be the discovery of sequences of physical interconnected movements to light a fire, where one of the intermediate steps involves noting that lightning causes trees to catch fire, and another might be that noting flint hitting rock creates a spark.

Bottom line: without "randomness", innovation is statistically unlikely, but associations *can* be demonstrated to be above pure chance, illustrated by Morales and Pineda's "Random samples method".[30]. It is postulated that randomness helps generate entirely new cross-associations that would otherwise never oc-

cur, due to the excessive Hamming distance. The problem is highlighted by Morales and Pineda as the *missing cue problem.*

6 Time-domain

For simpler organisms (simpler Consciousnesses) time-domain randomness becomes "directed trial and error". In other words, rejection of failures and reinforcement of successes, within the constraint of the environment. Morales and Pineda termed this a "Random samples method".[30] The next logical progression is to perform "chained" time-domain searches, which, again, Morales and Pineda term "Sample and Search method". These two methods are *by definition* time-based.

In nature an illustration would be Ants performing randomised searches (utilizing chemical signatures to keep track of previously-visited areas), or sniffer-dog tracking. In other words, the application of randomness occurs in the time-domain rather than the information-complexity-domain. However clearly there is scope for both strategies to be applied simultaneously: Higher-order Consciousnesses such as humans, illustrated by Edison's persistence on the light bulb, do so all the time.

7 Particle Swarm Optimisation

One key question: what is the equivalent of "lack of silence", in the physicality domain? In the complexity domain a pathological individual is expected to dwell on a particular thought or sequence of thoughts, for any given local context. In the physicality domain, where randomness is expressed through movement with respect to time, the expectation would be that individual has a tendency, to dwell in one location either unintentionally or explicitly. This type of pathological behaviour is *precisely* the well-documented limitation of the original and elegantly-simple Particle Swarm Optimisation algorithm.[31]

Ants and other creatures utilise chemical trails to overcome this problem, where the signature naturally fades over time, allowing the creature to potentially return to a location formerly visited, but not immediately. It also gives some insights into how to improve PSO by having a recorded history of at least the average position and intentionally moving away from that position if time dwelt within the locality is extended.

Another strategy, mirroring that of SDM, would be to form hierarchies of cooperative groups, equivalent to families tribes counties and countries, attempting to ensure at each level that the *group* conforms to the PSO rules, thereby satisfying the properties of a Banach space, covered below.

These types of strategies *may* help escape "local minima" traps. In Freito et al's study on the history of PSO:[32]

> "Wang et al., in 2013, proposed the Diversity Enhanced PSO with Neighborhood Search (DNSPSO),[33] a PSO variant that includes a new diversity enhanced mechanism using a crossover operation, and a new neighbourhood search strategy."

It turns out that combining alternative strategies with PSO can improve results in some cases but will always end up with a more complex algorithm. That being a given, the question becomes: is there any way to learn from the above, to create an effective algorithm that is also efficient and simple?

One angle to consider: can the success of Kademlia be applied to PSO? The expectation would be that in a Multi-dimensional environment, the answer would be almost by definition yes, the caveat being that the entire domain would require searching and categorisation according to SDM and Kademlia DHT criteria. This would be fine in a discrete domain but unacceptable in a continuous one, unless it can be demonstrated that quantization (discrete step size) does not exceed (mask) local minima variability. The Nyquist frequency best illustrates this concept. There is also the disadvantage of creating the categorisation in new domains.

An alternative approach would be to learn from neurons themselves: to apply the firing thresholds and response characteristics to the choices made by individual particles: both attraction *and aversion*, and to mimic the interconnectivity in such a way as to mirror SDM (and Kademlia) in some fashion. The quantity of strategies to try out is considerable and exciting, and worth exploring in its own right.

8 Banach spaces

Banach spaces[23] were highlighted in the work on Complexity Biology.[35] What stood out was that the mathematics of Banach spaces bears a remarkable resemblance to the properties of the algebra behind SDM. There are several clues, but the most important are firstly the convergence and secondly the parallelogram law. In both Kademlia and SDM, which has binary on/off values in every dimension, the parallelogram law emerges through the properties of XOR on a Hypercube.

The next step is to show that SDM is a generalisation of Hopfield networks, demonstrated by Trenton Bricken,[24] followed by showing a connection between Hopfield networks and Banach space.[25] Of particular importance is that the work by Alvarez, Diaz and Grau shows "periodic mild solutions" to the differential equations of a Banach space. The first significance in

the context of Freeman et al's EEG readings in brainwave patterns[26] should not be underestimated, nor that the solution - the expression of a given knowledge-state - is a repeating pattern rather than a static one. In other words: Hankey's multi-order critical instability. The second significance: periodic solutions is *precisely* the definition of looping, i.e. a crucial requirement for Consciousness.

9 Discussion

There is a lot to consider. The paper was supposed to be straightforward and highlight the importance of randomness as part of the Definition of Consciousness. However that required linking self-consistently to a wide range of topics previously explored.[8] There are hints that entropy is linked to Consciousness, by both Jha[34] and Mateos et al[19]. Further that Entropic measures have been noted by Carhart-Harris to accurately distinguish Glasgow-scaled medically-categorised levels of consciousness.[20]

However none make an *explicit* link to the crucial role of randomness in Consciousness, including in the work on Complexity Biology,[35] in which was proposed that Consciousness is associated with *Long-Range Order critical instabilities*, where Domash and Penrose also conjectured that Consciousness is associated with high levels of correlation. That LRO would "counteract" randomness was not explicitly spelled out, nor that a Banach space would fulfil Legendre's theorem.

Of particularly valuable interest here is Poznanski et al's work, theorising how the brain would encode consciousness through negentropic entanglement. They sought in particular non-electrolytic regions of neurons,[27] and, crucially as far as Complexity Biology is concerned, hint at critical instability oscillations in the electrons of proteins that are bound to actin filaments. A crucial step here would be to demonstrate that the properties of a Banach space, as a subgroup, are preserved by those electrons, given that LRO critical instabilities in the Complexity Biology proposal are postulated as *necessarily* being formed from *subgroups* of quantum critical instabilities.

Legendre

The deduction that the Universe is Conscious requires unpacking. However before doing so it is important to discern the difference between Knowledge, Consciousness, and *instances* of the same. Mahesh illustrated with an example: the key that discerns the DNA of an oak tree, an acorn, and the tree is: *time*. The DNA *contains* the knowledge, but the knowledge may only be expressed, applied, utilised and understood *in* an *instance* of Consciousness. Without this distinction the discussion below risks conflation between Knowledge, Consciousness, and *applications* of the two.

Legendre's theorem implies that the group and the subgroup belong to the same category - are the exact same type. There exist two plausible possibilities: either knowledge is a group, or the "discoverers" of new knowledge *themselves* - combined with the knowledge itself - is a group. In one case the Consciousness (smaller) beings, capable of *understanding* the knowledge indicates correspondingly the Universe must also be likewise Consciousness, and in the other the "individual's memory" is the subgroup and the Akashic Records the group.

A third possibility, hinted at from Complexity Biology,[35] is that the *knowledge itself* exhibits the properties of Consciousness, by exhibiting both O(N) critical instability characteristics and Negentropy, making it a peer of those that hold it, and thus satisfying the constraints described below on Banach spaces. Whichever way: the group and the subgroup are and *have* to be the same type, but regardless the implications are the same: Legendre's criteria is met.

Unfortunately, it is necessary to have communication across the planet (and planets and galaxies?) for the thoughts - the discoveries - to occur simultaneously, at which point "spooky action at a distance" kicks in. Fortunately this concept has been explored by Professor C D Yang[36][37] so is considered plausible (rather than proven).

However there are some very specific implications here: it *should* be possible to search for some mechanism and/or neurochemistry *within the brain* that performs quantum entanglement. The effect would have to be deeply comprehensive and complete, at every level of the brain i.e. within every neuron, on the basis that *if it existed separately* as a separate biological entity, it would have been found already. Could this be a side-role of proteins within actin filaments?[27] How could this be tested?

Conscious Universe

So it is shown that it is plausible that the Universe is Conscious, albeit on a fantastic scale. Almost as a casual aside this helps triage the theories as to whether the Universe will end after one cycle around its loop or whether it will continue: the Definitions of Consciousness tell us that looping is a corrective feedback mechanism, where auto-tuning PID Control[38] is a single parameter (qualia of size one), and the Universe a qualia of effectively-infinite size.

We know our Universe to be bounded, not infinite, from measurements of the Cosmic Microwave Radiation,[39] which has rather fortunate implications for the proposed PRNG, which need not be supplied by an infinite-sized seed, merely a fantastically-large

one instead.

There is also the rather heretical implication that if the Universe is synonymous with God, then God, whilst effectively all-knowing in the form of the Akashic Records being its Memory, the limited bounds of the Universe implies that God is similarly bounded. Alternative implications are that there exist infinite Universes, at which point God jumps back a step up to infinity, and the Galileo and Inquisition axes can be buried again.

Kademlia and SDM

Of particular interest is how far ahead Kademlia is, compared to current SDM and cognitive computing research. Kademlia already implements perfect traversal and perfect routing between addresses within an SDM, *without realising* the significance or the similarity to SDM. It was the common usage of XOR and that both are CAMs that sparked the investigation and found both to have formal proofs.

Looking closely at how nearest connectivity works: it is important to bear in mind that given any pairs of addresses, it is the difference between the pairs that results in clustering, despite wild difference in the (four) addresses. This it *literally* the textbook definition of Analogy. In other words: SDM and Kademlia DHT identify and locally cluster (and store in a Distributed fashion) material that is *inherently analogously interrelated*. This is a remarkably significant insight as it has implications for how self-directed learning occurs. However it requires that each Node in the SDM network has built-in processing capability (creating what is known in Flynn's 1972 Taxonomy as an "Associative Processor")[42] which is just another word for Tononi's IIT.[43]

To illustrate how processing capability emerges inherently from a Neural net: Hong and Pavlik's Randomly-weighted Fourier Network[1] implements the "part-of" operator in a purely feed-forward network. When Bernie Barrs GWT properties are implemented then Memory and Processing capacity are provided. In LIDA[17] there is a specific module called "Perceptual Associative Memory".[44] The similarity there to Kademlia is noted: both seem capable of chained logical deduction, both forward and reverse, but the dual capability is inherently down to the properties of XOR. Interestingly, the "Sample and Search" method developed by Morales and Pineda appears to implement the Kademlia algorithm.[30]

Further study into both the Copycat Architecture and Kademlia seems justified, and if there are architectural similarities then the mathematical proof of Kademlia will have significance for Copycat and consequently the PAM module in LIDA.

Entropic Hetero-Associative Memory

E-HAM is worth a special mention as it needs considerable further study.[30] The "sample and test" method is reminiscent of Ranjan and Gabora's "insights" work,[28], the combining of two independent functions is reminiscent of Complexity Biology's[35] combining of multiple quantum critical instabilities whilst preserving the properties of a Banach space, randomness recall is shown to have a success rate greater than chance, and much more.

For example: Bernie Barr's GWT requires a "Working memory"[16] and it was pointed out that IIT's primary "circuit" has the properties of a bi-stable latch.[8] The "sample and test" method *requires* a short-term "Memory" in order to perform the reverse-lookup and comparison, utilising the hetero-associative capability of E-HAM.

Overall the work is remarkable and ties in with a considerable amount of theoretical research.

Yoga

The practice of yoga is frequently misunderstood as being purely a sequence of physical movements and stretches: Ashtanga Yoga was developed by a student that did not wait until the full knowledge was given by a Guru. Yoga is in fact a group of practices designed *as a whole system* to get stress under control. The term "karma" is given to recurrent thought patterns outside of conscious control (worst case: PTSD) and have a well-established consequent detrimental effect on the body.[40]

Meditation, which is one part of Yogic practice, not only encourages (entices) the brain to calm down, the inducement (enticement) of silence, through randomised creative thought, provides the practitioner with a tool to escape a potential local minima of pathological thought, or other resource or physical environmental trap, that the practitioner finds themselves in. Which is remarkably practical: the word "spiritual" not having been mentioned once. The droll prospect is raised that, due to the risk of hitting local minima, Particle Swarm Optimisation algorithms could benefit from a bit of Yogic practice.

Overload

Worth noting that there could be other alternative benefits to Yogic Meditation. One possibility is based on overload of a given group of SDM neurons having too many cross-correlations running through it. There would be not enough information distribution, which would imply that a localised group is dealing with too large a Hamming distance. This would would be expected to result in the encouragement of local growth of new neurons in order to distribute the workload. The

expectation is that the *information* would become redistributed.

In the context of a Hypercube: one group of neurons is dealing with too many dimensions, routing and processing too much information, and alternative routes are needed.

A simple practical way to test the above hypothesis would be high-detailed fMRI scans with Q-Flow analysis to detect distributed hot-spots, as a new task or new challenge is encountered. Bloch's technique of utilising radio-markered brain-equivalent of stem cells would help.[41] The expectation is that firstly the hot-spots would be distributed, and secondly that the radio-markered microglia migrate *precisely* to those spots and reduce local workload.

The connection to Yogic Meditation, through silence, *could* simply be that the practice encourages the release of brain-equivalent stem-cells. Another benefit could potentially be that greater harmonic resonance, or greater coherence shown up consistently on EEG during Transcendental Meditation, results in greater efficiency: it's that simple. Considerable additional study is needed.

Banach spaces

One crucial observation[23] is that closed linear subspaces of Banach spaces are also themselves Banach spaces. This *on its own* is why Legendre's theorem applies. An additional insight is that the convergence is directed and there are no gaps. The best subjective way to express this is the feeling that the discovery or achievement is within reach. As the discoverer progresses, they *know* that they are on the right lines, and simply need time and resources to prove it. A classic example in the time/resource-domain is that of a sportsman who celebrates too early: the resultant mishap is the butt of jokes and exasperating ridicule throughout the ages.

Also worth noting is that Trenton Bricken mentions that Hopfield networks can be heteroassociative:[24] the caveat being that the "pattern address and the pointer" must be concatenated together, where SDM has separate input lines for key and value. Morales and Pineda likewise highlight the importance of Heteroassociativity, but fascinatingly the implementation is slightly different from Bricken's approach.[30]

The significance here is in the "self-awareness" discussed in earlier work,[8][9] where it was postulated that "experiencing" or self-awareness is a byproduct of the network circulating the lookup key as also part of the value returned *by the process of the lookup itself.* It is therefore fascinating to find that there is an underlying mathematical basis for "subject-predicate-object" loops, where the subject *and a part of the object* are the same.

The other crucial insight is from the observation that there are many ways to express the exact same knowledge: including that *multiple discoverers* or holders / experiencers of that knowledge. This is directly implied from Banach space, and from Hankey's observation that Critical instabilities are expressed as multiple quantum states.

All the pieces of the puzzle fit together, expressed in multiple ways, as highlighted within this paper. Ironically this very precisely demonstrates that the exact same knowledge can, in fact, be expressed in very different ways.

Particle Swarm Optimisation

The thought occurred to represent a hierarchical variant of PSO, creating groups with a "Grey wolf" at the centre of each, and the pack leader of each subgroup being the member of the next group up. A favourable aspect of this approach is that it scales linearly, as the overhead of maintaining the hierarchy does not involve the other members of each subgroup, merely the leader in each.

The approach takes into consideration the implications from Complexity Biology, that critical instabilities of an overall system are formed from combining smaller O(N) critical instabilities together, ensuring that both subgroup and group satisfy the properties of a Banach space. It is natural - more efficient - to apply this rule hierarchically, at which point - naturally - it becomes fractal in nature.

Qgrams and Supercomputing

TLSH[21] uses a "sliding window" of size five bytes to create locality-sensitive hashes. The exact same technique is utilised in relational databases to perform fuzzy-string matching: each chunk is termed a "qgram". Their sequential use - exactly as is done in TLSH - is termed an ngram algorithm.[45] The significance of Kondrak having created a formal definition of n-gram similarity and distance is not to be underestimated given Kanerva's[15] and Maymounkov's[18] work.

It is suspected that the eMule Network utilises q-grams or similar to perform multi-word or multi-phrase "fuzzy" searching. Contrast this with Kademlia which requires *full* knowledge of the torrent hash in order to utilise Kademlia chain-hopping to traverse from node to node with guaranteed-increasing similarity.

The similarity to PAM[44] should not go unnoticed, however the success of all these techniques has implications for both Distributed Database design and for Supercomputing: specifically the databases *used* for Distributed Computing. It would not come as a surprise

to discover that huge efficiency increases are achieved if the workloads for Distributed Computing are greatly improved firstly by establishing an approximation to Hypercube connectivity, and secondly by "grouping" algorithms together based on a TLSH-style "hash" of the work to be done and, specifically, the degree of inter-dependence on data locality.

One very simple alternative way to encode such would be to utilise the Qualia concept, where each algorithm is categorised by its use of a particular data type, resource, or other information. The sequence of such dependencies becomes the qualia, and inherently due to the properties of SDM it would be expected that processing migrate to nearest-neighbour nodes with similar Hamming distance of their need to share information or access the same resource.

Almost as an aside: a beautiful and startling observation is that use of such techniques, by virtue of the inherent adaptability, would imply that the software managing the migration of data to ensure efficient distributed optimisation of the Supercomputing cluster *meets Definitions of Consciousness.*

As explained in the paper on Epigenetics[9], O(N) distributed response can also have distributed "detection" and still maintain Critical Instability. In the case of individual Computing Nodes, the expectation would be to measure local Node temperature including hard drives and the main CPU, local Node CPU workload, and local network bandwidth connectivity. Even without Integration wrt in a given O(1) PID Control managing the Node, the Convolution of the Nodes PID to produce an O(N) Epigenetic response - would provide the missing Integration for a system-wide adaptation. In this particular case however the Convolution would naturally be assumed to be based on weighting by Hamming distance, as opposed to physical distance, such as in PSO. However until investigation begins it would be unwise to pre-judge.

Again almost as a casual aside, the similarity of the problem of Distributed Supercomputing to large-scale logistics management should be noted, indicating that once again the effectiveness of the underlying capability and mathematics of SDM has far more application than could have been predicted.

Shravas Rao

Shravas Rao highlights many references to such applications.[47] Initially a search was performed as a simple example application of how a well-known algorithm such as a Fourier Transform could be distributed across a Hypercube network. However, rather surprisingly, the paper references *Hamming distance* as part of the formal proof, which is of course the basis of SDM. Also mentioned is that:

> the eigenvectors of a symmetric matrix with different eigenvalues are orthogonal.

The significance of the Gram-Schmidt procedure[48] is that it *makes all vectors orthogonal.* However the big significance of Rao's paper is that it is *another* mathematical proof of the same underlying concept as SDM and Kademlia. Knowledge *really does* get expressed in many different ways.

It is also worthwhile mentioning that the Fourier transform is expressed recursively, in terms of "divide and conquer", resulting in a Butterfly network. Each layer combines two halves: the significance here being reminiscent - once again - of Complexity Biology's Banach spaces. Manuel et al highlight that a butterfly network is a "bounded-degree derivative" of the hypercube.[49] The implications here are that the properties of SDM *inherently reflect those of a Fourier transform* or more specifically in Computing terminology: recursive frequency-hierarchical mapreduce.

The similarity may be perceived on recognition that the addition of one more dimension in a Hypercube, the existing Hypercube is duplicated, and then lines drawn between every corresponding point on the two duplicates. Each layer therefore naturally corresponds to one bit of a binary number, increasing to the next order of a Hasse diagram. Manuel et al Figure 1b fascinatingly representing a Hasse diagram of Order 5, where three of the dimensions are expressed in binary $000-111$ and the remaining two as the integers $0-3$. The significance is that the range of each is the number of rows and columns in Figure 1a. That Hasse diagrams are connected to Lie algebra has not gone unnoticed.

Worth exploring further given that Navier-Stokes equations in Computational Fluid Dynamics are solved with Lie Group analysis, and the fact that Banach spaces are used:[50] the relationship between a Hypercube and Lie Groups is called the Hyperoctahedral group.

Evolution

From an Evolutionary perspective, given the cost of carrying around any given knowledge or data or structure, if there is a choice to carry around the raw data vs a compressed version of that data, Evolutionary pressure will inherently favour the most efficient encoding. True randomness (white noise) is the exception, but even pink noise will be more efficient to store.

Beshkar postulates that Consciousness acts as a "cooling mechanism for the brain".[46] This paper postulates that the increased heat from over-exertion is a *direct evidential side-effect* of the inefficiency of directly storing incompressible chaos - aka randomness.

> Evolution is a function of *efficiency.*

Laws of Nature

It is crucial to note that observation (detection) of Negentropy does not *define* Consciousness. Rather, that the detection indicates the *presence* of Consciousness at work, at some level and to some degree.

Exactly what "Consciousness is at work" in any given context *cannot be nailed down*, but the key is that the other aspects of Consciousness *should* also be present, from the other Definitions of Consciousness. This raises an interesting addendum when testing for Consciousness:[51] how does the entity react in the face of chaos (infinite entropy). As the simplest canonical guide: analysing an auto-tuning PID Controller faced with entirely random input and/or output would make a fascinating study.

Holographic and Holonomic

Pitti Weidmann and Quoy's sparse representations would seem to create a uniform distribution of ordinal codes[2], i.e. diffusion occurs, the key being as illustrated by SDM's redundancy that a uniform multiple of *sparse* links to a given code *should* be a given, as further illustrated by Hong and Pavlik.[1] Another possible phrase describing such is "Holographic". When applied to SDM, another way to describe such would be "Holographic Memory", with echos of Ervin Laszlo's Holofield.[11] However as noted above, with the Akashic Records reasonably concluded to be the SDM of "God", aka "a fantastically large Consciousness", it is not unreasonable to further deduce and describe SDM *as a concept*, regardless of size implementation or usage, as being Holographic in nature.

Also, Pitti et al demonstrate a *hundred million-fold* encoding capacity compared to an individual neuron, which would tend to support the hypothesis of the information being holographically encoded. They then found parallels with Shannon's "separation theorem", which relates the storage or channel capacity to the *entropy* of the system. Pitti et al point out that the key insight from Shannon was that the *right encoding* could significantly increase efficiency. Once again: *efficiency* is highlighted.

Moving on to Alemdar et al's work[52] they comprehensively and insightfully discuss Karl Pribram's Holonomic Brain Theory.[53] Alemdar et al point out that Pribram's perspective was not that the brain operates at a quantum level, but that the theory is *formally equivalent* to computations in quantum mechanics, and, further, that there would not *necessarily* be "direct correlation" - i.e. no Neural Correlates of Consciousness, no *necessarily* delocalised electrons, on the basis that the information was holographic in form: "holowhen" and "holowhere".

This perspective, given that Holographic storage is considered a form of Fourier transform, could simply be that Pribram preferred to think in terms of Fourier transforms instead of explicit quantum qubits (not to be confused with QFT). A timely reminder is needed, here, that Hong and Pavlik's Randomly-weighted Fourier Network[1] showed huge effectiveness and efficiency, *without* referring to QM.

Alemdar et al then point out that the fractal perspective of Self-Organised Criticality as outlined in Complexity Biology[35] is unproven, and propose an alternative: termed modular holarchy, or modular holographic hierarchy, illustrated in Figure 1.[52] However on closer inspection, the similarity to Complexity Biology and Fractal physiology seems remarkably close, rather than contradictory. Brandas is referenced as having explored Negentropic entanglement through Long-Range Order using a Fourier-Laplace Transform to do so,[54] and Wang et al's fluctuation theorem[55] *supports* the perspective of Complexity Biology, being at its heart LRO Critical instabilities. In fact, Alemdar's Figure 1 illustrating Negentropic entanglement highlights the *very same Banach space subgrouping* expected of Consciousness operating in a hierarchical and fractal fashion, each being themselves a Banach space operating at Critical instability. Note here that a Banach space is also a Hilbert space and that *Brandas proves a general Fourier-Laplace relation*

The question becomes, then: why did Alemdar et al conclude that the brain is *not* operating fractally? There is the possibility that both perspectives are correct, on the basis that behaviour of humans can be seen to be no different from "parroted by-rote responses", illustrating that whilst the potential for Conscious behaviour is within the grasp of the human neuronal physiology, it is not *necessarily* exhibited in every instance.

The second perspective could be that the significance of Pitti Weidmann and Quoy's observations on Shannon were simply missed. And a third perspective could be that whilst Fractal physiology is evident within the brain, such as in the growth of dendrites branching out randomly, this *does not necessarily* translate *directly* onto the way that information is holographically encoded and stored within the brain. However, again, Pitti et al tantalisingly hint that their work implies exactly that, as explored herein on the properties of SDM.

Likewise the reference to Srivastaba and Sampath utilising the Gram-Schmidt procedure[48][56] to shows that procedure to be utilising the *exact same process* of LLMs to implement "Analogy".[22]

Overall, from many many angles it can be surmised that there appears simply to be a "difference of perspective" in Alemdar et al's remarkable work.

General

It is crucial to bear in mind that both domain-dependent and time-dependent complexity can face similarly-sized qualia and information (in the form of environmental and resource complexity). A reminder that Consciousness increases in capability to match the corresponding increase in environmental and resource pressure. Put another way: in the case of time-domain application the simplicity of the individual Consciousness should never be underestimated, as richly demonstrated by a wealth of astonishing and delightful Nature documentaries. As a hint: the fact that random recall demonstrated by Morales and Pineda only has a slightly greater-than-chance probability of success[30] may be *augmented by persistent trial-and-error in the time-domain*. The phenomena is easily demonstrated by $(1-N)^N$ rapidly converging to zero as N increases.

The perspective that the Universe will end after just one cycle is very common: expansion followed by contraction for example. However an alternative perspective is hinted at from any given Universe being an absolutely massive Consciousness. It implies that each "cycle" of light round that Universe is the equivalent of one Renshaw Loop iteration, or one auto-tuning PID Controller's computation, or one cycle of the photon around the Ring Model, or one frequency beat round the Thalamo-circuit, and so on. The most plausible explanation as to why the perspective is not widely considered is likely down to the multitude of orders of magnitude difference between the operational speed of Human and Universe consciousnesses.

Also worth pointing out that Negentropy is not a violation of the Laws of Thermodynamics. It turns out that the creation of coherent information (aka Knowledge) as stored within a Consciousness results in output of waste byproducts such as heat and effluent that exactly match the Negentropic value of the knowledge. The irony of randomness effectively defeating its own entropy is not lost.

A pertinent theoretical question inspired by this work: if a Hypercube of dimension four can be broken down effectively into two sets of the utmost basic form of "Analogy" by forming two rectangles, where the "difference" on each edge represents the XOR change of the respective dimensions of each pair, what insight does the relationship to the Klein four-group give about Logical Inference, when combining any two Analogies?

Lastly: how does the connectivity between neurons result in SDM? Put another way: how does the neuron know to connect, in an SDM, to similar qualia? The answer as usual may lie within the question, given SDM's algebra, but there may be more to it, given that clusters of galaxies form such remarkably-similar structure.

10 Conclusion

An exploration of randomness being the source of all thought threw up links between what would otherwise be considered wildly different areas of research. At the core is Sparse Distributed Memory (SDM) and the Kademlia Distributed Hash Table (DHT), both of which are key-value stores based around the properties of XOR and Hamming distance, both of which invoke the same underlying algebra and both of which have mathematical proofs: one extending the other. Gabora and Ranjan's theory invited an additional perspective of an intermediary random qualia that overlapped sufficiently with both, so as to trigger - or become - the "creative innovative link", and it was observed that LIDA's Perceptive Associative Memory (PAM) has similarity to Kademlia, worth exploring in-depth.

Tononi's IIT[43] assumes that processing is built-in to every Node (or in the case of neurons, additionally in the connectivity *between* neurons). It is postulated that the automatic local-clustering of qualia with similar Hamming distance allows for Analogy ($A-B=C-D$ and $A-C=B-D$) to *emerge*, as demonstrated by PAM. In other words: the missing insight is Tononi's IIT *emerges* from not just the built-in processing but from SDM network topology, rather than is explicitly "built-in". Hong and Pavlik's Random Fourier Feature, and Pitti Weidman and Quoy's "sparse coding" and many more all consistently demonstrate this "Holographic" property. The effect is similar to how efficiency *emerges* from Evolution under resource pressure and environmental complexity, and the distributed requirement *driven by that efficiency* inherently excluding chaos finally gives the answer as to why knowledge subdivides knowledge, backed up by the properties of Banach space, of which SDM is a generalisation.

Pictures comparing neural networks to galaxies are virtually indistinguishable, hinting that there is an underlying mathematical / algorithmic pattern right across the board: it is postulated that this is Consciousness, or its definition, and that randomness is just an equally important characteristic as those highlighted by McKenzie (Memory, Perception, Imagination and the iterative feedback between them).[57] Again this has implications for PID Control: could the deliberate introduction of random fluctuations help dampen hysteresis, or is it just that PID Control inherently helps with noisy input?[3]

Time-distributed randomness is especially fascinating: it's not truly random (pink noise rather than white) as illustrated by Ant chemical trails causing localised aversion and attraction, ultimately resulting in Negentropy achieved in a time-sequential fashion.

The bottom line here is that for any given Consciousness, the crucial role of randomness in Memory, notably

in the use of SDM and its biological implementations (brains) has been highlighted as a paradoxical way to overcome entropic increase rather than feed it. The implication being that when Negentropy is found hiding in plain sight amongst randomness, Consciousness *has* to be present. Hankey expresses this as:

> "(critical instability) correlations endow a system with a form of order i.e. *negative entropy*"[35]

Worth exploring further: the driving factor being, ultimately, efficiency of encoding, implying that chaos - the storing and carrying of randomness by any given Consciousness - is *heavy*.

Chaos *literally* has weight.

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