Arrow of time and neuroscience: TGD based view

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Abstract

The question that inspired this article is whether memories about the future - precognitions - are possible in some sense. This requires retrocausality. The criticism of retrocausality relies on the assumption that time, in particular the thermodynamical time, has always the same arrow. TGD inspired theory of consciousness as quantum measurement theory based on zero energy ontology (ZEO) predicts that the arrow of time can vary and changes in ordinary - "big" -state function reductions (BSFRs): self dies (falls asleep) and re-incarnates with a opposite arrow of time. This leads to a generalisation of thermodynamics and allows to see self-organisation basically as a consequence of the generalised second law.

Precognition as a recall of future geometric memories would rely on sensory perception with an opposite arrow of time by some sub-selves assignable to the structures of the brain. The arrow of time would be reversed at some layer of the magnetic body in a master-slave relation with the biological body and induce an effective change of arrow at the level of ordinary biomatter in longer time scales than usual. The sensory perceptions with reversed arrow time would be communicated to the self as dreams meaning BSFR for the time reversed mental and its death and reincarnation with standard arrow of time. There are findings about Alzheimer patients supporting this hypothesis.

This proposal deviates from standard neuroscience in that ZEO and the notion of magnetic body carrying phases of ordinary matter with effective Planck constant $h_{eff} = nh_0 > h$ behaving like dark matter. Also a purely biochemistry based hypothesis that biochemical factors responsible for the buildup of memory traces select the arrow of time: perhaps their shortage could lead to the selection of the opposite arrow of time.

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1 Introduction

The question that inspired this article is whether memories about the future are possible. This requires retrocausality. The criticism of retrocausality relies on the assumption that time, in particular the thermo-dynamical time, has always the same arrow.

If one gives up this assumption, there is no reason forbidding retro-causality and phenomena like sensory perception of signals arriving from future giving rise to precognition. In fact, our ability to predict a lot about our future might be due to this kind of sensory perception rather than only due to computation using a neuronal model.

There is empirical evidence for non-standard arrow of time. Phase conjugate light rays [Zeldowich and Shkukov 1985] (`https://cutt.ly/ys4x4dX`) obeying second law in wrong time direction, Fantappie's work [Fantappie 1942, Vannini 2007], self-organization in biology - the self-assembly of the tobacco mosaic virus is a classical example [Butler 1999]. The latest finding that I learned of is that an isolated system can extract organized energy from its thermal energy [Kuzkin and Krivtsov 2020] (`https://tinyurl.com/y9ycj3nt`).

In the framework of Topological Geometrodynamics (TGD) zero energy ontology (ZEO) [Pitkänen 2020b] leads to a quantum measurement theory solving the basic problem of standard quantum measurement theory due to the conflict between determinism of Schrödinger equation and non-determinism of quantum jump. Key prediction is that the arrow of time changes in ordinary "big" state function reduction (BSFR) whereas in "small" state function reductions (SSFR) analogous to "weak" measurements the arrow of time is not changed.

This forces a generalization of thermodynamics and dissipation with opposite arrow of time allows to understand self-organization and also energy feed necessary for it in terms of generalized second law. A system dissipating in non-standard time direction seems from the point of view of the outsider to develop structures and extract energy from the environment. The non-standard arrow of time would be associated with the magnetic body (MB) carrying $h_{eff} = nh_0$ phases of ordinary matter identifiable as dark matter and making it a macroscopic quantum system for sufficiently large values of n. MB would act as master of the ordinary matter and induce effective time reversal at the level of ordinary matter in long time scales.

The TGD view about the neural system differs from the standard picture.

1. The first new element is the different role of nerve pulses: they create communication pathways along which dark photons can propagate.

2. Second new element is the presence of linear flux tube structures assignable to neural pathways assignable to linguistic cognition unstable against effective axonal splitting occurring in Alzheimer disease (AD) [Bredesen 2017], and the presence of 2- and even 3-D flux tube structures assignable to geometric and holistic cognition: this would survive in AD [Pitkänen 2018b] and in states involving cognitive defects (idiot savants). Meridian system and glial cells could relate to this aspect.

   Communications in this system would be based on dark photons transforming to bio-photons and travelling along flux tubes with light velocity. This system would be the predecessor of the neural system and could be realized even in the case of plants. In the neural system the real communications would rely on dark photons - ordinary photons with effective Planck constant $h_{eff} = nh_0 > h$.

The communication lines would be dynamical consisting of axonal flux tubes connected by nerve pulse transmission to longer structures serving as wave guides along with dark photons signals would propagate. Metabolic economy could motivate this kind of realization as for electronic communications in modern society. Nerve pulses would only build the connection lines for communications inside the brain. They would however modulate the frequency of Josephson radiation from neuronal membrane to the MB of the brain and in this manner communicate sensory data from cell membrane to MB.

3. According to ZEO based theory of consciousness causal diamond (CD) identified as CD $= cd \times CP_2 \subset H = M^4 \times CP_2$, where H denotes 8-D imbedding space containing space-time as 4-surface, and cd is the intersection of future and past directed light-cones in 4-D Minkowski space M^4 and CP_2 is 4-D complex projective space. The passive boundary would correspond to holistic, spatial, and the timeless component of conscious experience dominating in meditative states and active boundary to reductionistic, temporal part of conscious experience such as sensory perception and cognition. These components correspond to opposite arrows of time at certain layers of MB.

4. I have considered the realization of the holistic emotional intelligence in terms of the notion of bio-harmony [Pitkänen 2014b, Pitkänen 2014c, Pitkänen 2019a]. Here one must however remember that emotions could be sensory percepts at the level of MB so that they should correspond to the dynamical aspects of consciousness rather than the permanent part. Music expresses and induces emotions and harmony codes for the emotional state. A model involving icosahedral and tetrahedral symmetries leads to a model that Pitkänen calls bio-harmony: the model predicts correctly the basic aspects of the vertebrate genetic code. The codons would correspond to 3-chords of bio-harmony. The realization of bio-harmony is assigned with magnetic bodies of the basic biomolecules including RNA and DNA.

5. EEG frequencies $f > 10$ Hz assigned to wake-up consciousness could correspond to the effectively 1-D and "linguistic" neural system and frequencies $f < 10$ Hz to the system responsible for holistic aspects. During sleep $f < 10$ Hz dominates so that the consciousness should be holistic. Since we do not remember anything about this period, it could correspond to time reversed mode making possible precognition as sensory perception of signals from geometric future.

6. The effective change of the arrow of time in the neural system induced by its real change at the level of MB could mean the change of the direction of nerve pulse conduction. This reversal could explain phenomena like reverse writing and reverse speech discussed in [Pitkänen 2006a]. There is evidence that AD patients have precognitive and prophetic dreams [de Pablos 2002, de Pablos 2005]. Ordinary nerve

pulse conduction is prevented in AD by axonal plaque and exponentially attenuated. In the reverse time direction there would be an exponential amplification with respect to standard direction of time. This suggests that AD neurons are dead in standard time direction but re-incarnated in the opposite time direction. Death would be a gradual process.

This proposed hypothesis is testable. To hold true, manipulation of the level of acetylcholinesterase inhibitors (AChEIs) should reduce the formation of past event memory and increase the formation of future oriented precognitive memory traces. Indeed, there is evidence that Rivastigmine, a reversible ACEI used in the treatment of AD, increases memory and rapid eye movement sleep, and has been suggested that aside form those normal properties it could be implicated in retrograde dream formation, i.e., precognitive dreaming [Seelye et al 2009]. Similar pilot study has yielded same results before [de Pablos 2002].

Further support comes from the bidirectional relationship between AD and sleep disorders through a model of brain rhythm attractor breakdown [Karageorgiu and Vossel 2017]. In fact, individual differences were found in prophetic dream belief and experience, with a high frequency of prophetic dream experiences associated with disordered sleep patterns and sleep medication use [Valasek and Watt 2015].

In the sequel this picture is discussed in more detail. In particular, the question how the possibility of non-standard arrow of time could make possible precognition as sensory perception of signals from geometric future, is considered. Our ability to predict our future is usually regarded as trivial. Computationalists explain it by assuming that the brain is a computer predicting the future. This ability could involve this sensory perception in an essential manner.

2 Some aspects of TGD inspired quantum biology and theory of consciousness

2.1 TGD based quantum biology very briefly

One can approach TGD inspired quantum biology by making questions.

2.1.1 How to understand coherence of living systems?

If only bio-chemistry is involved, we would be sacks of water and sacks of water do not climb in trees or write poems. Could quantum coherence induce the coherence? What entity serve as intentional agent and how it could realize its intentions?

1. Topological field quantization applies to electric and magnetic fields [Pitkänen 2010a, Pitkänen 2010b]. For instance, magnetic field decomposes to flux tubes having finite thickness. Radiation fields are topologically quantized to topological light rays.

Each system has its fields at separate space-time sheets touching each other only via wormhole contacts: system has field body, in particular magnetic body (MB) having hierarchical onion-like structure corresponding to the hierarchy of space-time sheets. Magnetic flux tubes would take a role analogous to wormholes in the ER-EPR correspondence proposed by Maldacena and Susskind [Maldcena and Susskind 2013] in GRT context serving as topological correlates and prerequisites for entanglement.

2. MB serves as the intentional agent using biological body (BB) as motor instrument and sensory receptor. MB controls BB via dark photon dark photon beams with large h_{eff}. The double BB + environment is replaced with the triple MB + BB+ environment. The vision about life as nothing but biochemistry is given up.

3. Experiments of Blackman [Blackman 1994] and others demonstrated the quantal effects of extremely low frequency (ELF) radiation - say in EEG range - on vertebrate brain. For the ordinary value of Planck constant these effects are however impossible since the energy $E = hf$ of EEG photons is extremely small. This motivated what eventually became $h_{eff}/h_0 = n$ hypothesis derivable now from adelic physics [Pitkänen 2017a].

4. Dark matter at the flux tubes of MB corresponds to $h_{eff}/h_0 = n$ phases and induces coherence of visible living matter. The generalization and re-interpretation [Pitkänen 2006c, Pitkänen 2015a] of Nottale's hypothesis [Nottale and DaRocha 2003], which reads as $h_{eff} = h_{gr} = GMm/v_0$, where $v_0 < c$ has dimensions of velocity and M and m are masses at the ends of the magnetic flux tube along which gravitons travel is essential element. The hypothesis implies that the cyclotron energy scale for charged particle is independent on m. The spectrum of Josephson frequencies for cell membrane is universal but now the energies are inversely proportional to h_{eff}. The flux tubes containing dark matter would make possible essentially dissipation-free communications based on supra currents and on dark photons.

2.1.2 How MB uses BB as sensory receptor and motor instrument?

How does MB use BB as sensory receptor and motor instrument?

1. Dark photons with large h_{eff} serve as as communication and control tools. Josephson frequencies would be involved with the communication of sensory data to MB and cyclotron frequencies with control by MB. Dark photons are assumed to transform to bio-photons [Bischof 2005] with energies covering visible and UV associated with the transitions of bio-molecules [Pitkänen 2013c, Pitkänen 2013b]. The control by MB which layers having size even larger than that of Earth means that remote mental interactions are routine in living matter.

2. In ZEO field body and MB correspond to 4-D rather than 3-D field patterns. Quantum states are replaced by quantum counterparts of behaviors and biological functions. The basic mechanism used by MB would be generation of conscious holograms by using dark photon reference beams from MB and their reading. In ZEO also the time reversals of these processes are possible and make possible to understand memory as communications with geometric past. Sensory perception and memory recall would be time reversals of each other and correspond to sequences of SSFRs. Motor action would correspond to BSFRs.

2.1.3 Why metabolism?

Particles with nonstandard h_{eff}/h_0 have higher energy as a rule. For instance, atomic binding energies are proportional to $1/h_{eff}^2$ and thus smaller. Cyclotron energies are proportional to h_{eff}. Metabolic energy is needed to excite particles to dark states and thus to increase their "IQ" .

This picture suggests a generalization of the view about self-organization based on non-equilibrium thermodynamics with a quantum view based on number theory, in particular the hierarchy of Planck constants [Pitkänen 2019c]. In non-equilibrium thermodynamics energy feed is a prerequisite of self-organization leading to a generation of coherent structures in long length scales and master-slave hierarchy is central. TGD can be at least formally seen as complex square root of thermodynamics, which leads to the question whether also ordinary self-organization could reduce to the hierarchy of Planck constants so that quite generally the coherent structures in long length scales could be seen as analogs of life forms with coherence induced by quantum coherence at the level of MBs. Hierarchy of MBs defining master slave hierarchy with ordinary matter at the bottom of the hierarchy would replace ordinary master slave hierarchy and quantum theory would make itself visible in all scales.

2.2 Some aspects of ZEO based theory of consciousness

2.2.1 Active and passive aspects of conscious experience in TGD vision

In the TGD framework one can understand the presence of the temporal, active and passive aspects of consciousness at the fundamental level.

1. In ZEO conscious entities have as geometric correlates causal diamonds (CDs) having two light-like boundaries. The quantum states are products of analogs of ordinary quantum states assignable to these boundaries and the state is in the general case superposition of these state pairs meaning time-like entanglement.

2. During the life cycle of self the active boundary of CD drifts farther away from static passive boundary in statistical sense and the members of state pairs at it change during the sequence of SSFRs. The contribution of the active boundary to conscious

experience corresponds to a sensory input and cognition and changes with time:this gives rise to the experience of time flow.

3. The 3-D states at the passive boundary are identified as superpositions of 3-surfaces remaining unaffected in SSFRs. The 4-D tangent planes of 4-surface at them however change and contribute to conscious experience. This contribution would be almost constant, holistic, spatial, and "timeless" and dominate in meditative states where sensory and cognitive input assignable to the SSFRs is minimal. This contribution would correspond to "soul".

In the popular literature about brain science these two contributions are often assigned with the left and right hemisphere. This assignment is certainly over-exaggeration but might have some seed of truth if considered at the level of many-layered MB and taking into account the hierarchy of CDs.

1. Could evolution favor formation of systems for which MBs tend to appear in pairs with the first member in active state and second member in passive state.

   The members of the pair need not have an opposite arrow of time. One can however imagine two parallel sub-CDs of CD with opposite arrows of time and shifting towards geometric future with the active boundary of CD - this shifting is necessary since mental images of CD shift to future. The active contribution from sub-CD_1 and passive contribution from sub-CD_2 would correspond to the same value of experience time inside CD.

   CD_1 would certainly give sensory input. Could CD_2 give a meditative contribution masked by CD_1 except in meditative states?

2. Pairings of nearly identical systems are very general in living matter [Pitkänen 2006b]. Basic examples are brain hemispheres and also pairs of identical sub-systems inside left and right hemispheres. The strands of DNA provide the second example: given strand has both active and passive portions and there is active-passive pairing. Lipid layers of the cell membrane and epithelial sheets associated with skin have two cell layers giving rise to a binary structure. Whether the active-passive dichotomy applies also now - perhaps at the level of their MBs - is an interesting question.

   Having both arrows of time would make possible sensory input from both past and future and make possible to both remember and predict. This would certainly increase the changes of survival.

3. Could the members of these pairs change their roles by changing their arrows of time? Kind of division of labour would be in question. Some birds (swift for instance) fly always and the explanation is that the second hemisphere sleeps when another one is in wake-up state [Rattenborg et al 2016, Liechti et al 2013]. Could this happen during sleep for some neuronal functions also in humans? Or do both hemispheres remain neurally passive during sleep?

2.2.2 Redefining the basic concepts related to time in ZEO framework

TGD based quantum measurement theory extending to a theory of consciousness relies on what Pitkänen calls zero energy ontology (ZEO) [Pitkänen 2020b]. In this framework experienced time and geometric time are not anymore identified. This has strong motivation, since although these times are strongly correlated, they differ dramatically in many respects. This compels to study every standard concept separately and see how it changes. The new ontology forces to reconsider various basic definitions.

The notion of event

The notion of event has many meanings.

1. Einstein regarded event as a space-time point. Event refers to subjective experience and in the geometric framework it is more natural to talk about space-time point.

2. Events can be identified a classical states assignable to time= constant snapshots of space-time in standard ontology: basically initial values for the time evolution dictated by field equations.

3. In ZEO event in classical sense can be regarded as a classical time evolution - preferred extremal connecting 3-surfaces at the opposite boundaries of CD and analogous to Bohr orbit dictated by the boundary values at either boundary of CD - 3-surface. The analogies with behavior, biological function, and computer program are suggestive.

   Strong form of holography (SH) allows to fix this surface by using 2-D data associated with partonic 2-surfaces and string world sheets. A weaker condition is that the 2-dimensionality for partonic 2-surfaces corresponds to the metric 2-dimensionality for their topologically 3-D light-like orbits. The quantum counterpart of event would be zero energy state identified as a superposition of these space-time surfaces - quantum behavior.

4. Conscious event could be also seen as a state function reduction: moment of recreation identifiable as an act of free will. There are "small" and "big" state function reductions: SSFRs and BSFRs. SSFR is the analog of weak measurement and BSFR corresponds to the ordinary state function reduction identifiable in ZEO as "death" of the conscious entity defined by the sequence of SFRSs and "reincarnation" with opposite arrow of time. These notions would be universal, not only biological.

The notions time and causality

For the notions of time and causality doubling takes place. There are

1. Two times - subjective and geometric.

2. Two causalities - that of free will/BSFRs for sub-CDs and that of classical field equations.

3. Two arrows of time. Also the thermo-dynamical arrow of time can be non-standard. This leads to a totally new view about self-organization. Retrocausation (subjective and geometric) becomes possible.

4. Two kinds of memories - subjective memories possible only about subjective past (one cannot remember what one has not experienced yet). and geometric memories about external world, which can also be about geometric future. In the latter case one can speak about precognition or sensory perceptions of geometric future.

The geometric counterpart of subjective "Now"

What geometrical correlate does the subjective "Now" have?

1. The first proposal was that it corresponds to the active boundary of CD. It however turned out that the subjective "Now" could more naturally correspond to the $t = T$ slice of CD with maximal size located in the middle of CD. Here t corresponds to linear Minkowski time axis connecting the tips of CD.

   If one accepts $M^8 - H$ duality, this picture can be made precise. The moments "Now" would correspond to "special moments in the life of self" [Pitkänen 2019b, Pitkänen 2020a] identifiable as intersections of 6-spheres, which are brane-like entities (branes are encountered in M-theory) appearing as universal special solutions of algebraic equations determining the space-time surfaces in M^8_c. The values of T correspond to he roots of the real polynomial defining the space-time surface so that the values of "Now" are quantized.

2. During the sequence of state function reductions the active boundary of CD would shift towards geometric future and the size of CD would increase (in statistical sense). The sub-CDs accompanying sensory and other mental images would shift to the direction of geometric future as CD increases and become potential memory mental images suffering BSFRs in a shorter time scale.

   The self would experience memory mental image as a sub-self in memory recall to be discussed below. The time=constant snap-shots at the upper half of CD assignable to the memory mental images are ordered with respect to the Minkowski time t but the order is opposite to that for the subjective experiences. This was a great surprise to me. They would correspond to subselves to which memory recall builds a connection by entanglement quantally or by sending a signal, which is reflected back in BSFR for the memory mental images.

The recall of the episodic memories

What about recall of episodic memories in ZEO?

1. Spontaneous memory recall could correspond to a death of a memory mental image with opposite arrow of time and re-incarnation with the same arrow of time as self. This could be accompanied by emission of past directed "negative energy" signal received by self associated with moment "Now". The interpretation would be in terms of extraction of metabolic energy: memory recall indeed requires metabolic energy.

   Active memory recall could correspond to a receive of future directed "positive energy" signal coming from "Now" having interpretation as metabolic energy feed. Energy conservation would force the memory mental image to change the arrow of time.

2. The prediction would be that in active memory recall by a "positive energy" signal received by the memory sub-CDs, the order of recalled memories is opposite to that for the real experiences. There is evidence for this kind of change [Linde-Domingo et al 2019] (see also the popular article "The human brain works backwards to retrieve memories" at `http://tinyurl.com/y7hbqmug`).

3. One also consider a mechanism based on time-like quantum entanglement between the memory sub-self and sub-self associated with "Now".

Two variants for geometric memories

Geometric memories - non-personal "memories" - about the external world seem to be possible. The information would arrive as signals from the external world (exterior of CD) and would be "objective". Signals can arrive also from the interior of CD. For instance, as light-signals affecting the state at the active boundary of the CD at which also personal memories are stored. The states are not changed at the passive boundary of the CD during the life cycle of self.

Geometric memories come in two variants corresponding to the two arrows of time.

1. The sensory input from the external world of the geometric past could generate geometric memories, most naturally memories in the behavioristic sense meaning changes of the behavior induced by the changes of synaptic strengths. Sub-selves with an opposite arrow of time could have geometric memories also from the geometric future and give rise to geometric precognition. During sleep this could occur.

2. The geometric memories about future - geometric precognitions or sensory perceptions of signals from future - would be what we regard as an ability to predict what happens tomorrow or after one year. They would not be absolute since quantum jumps affect also the future in scales longer than that for my personal MB. Usually these memories would be identified in terms of a model for the behavior of the external world. Physics itself would realize this model.

3 Holistic and reductionistic aspects of cognition at the level of brain

3.1 New view about the role of nerve pulse transmission in brain communications

Usually nerve pulses are regarded as signalling in brain. In TGD framework the situations changes [Pitkänen 2018a].

1. Axons would be accompanied by flux tubes - actually closed flux tubes with a shape of very narrow and long parallelogram. Nerve pulse transmission connects the flux tubes associated with pre- and postsynaptic neurons to longer flux tubes. Nerve pulses make possible real communications by dark photons by creating connected signal pathways from pieces. Dark photon communications are much faster than neuronal ones. There is an analogy with modern electric communications. Communications lines are dynamic and created before communications using relays to save energy.

2. There is dark photon feedback from the brain or even "large" layers of MB to sensory organs giving rise to virtual sensory input. This feedback leading to a stationary situation would make possible pattern recognition producing standardized sensory mental images as kind of artworks by feedback leading to a stationary situation. Light velocity allows very large number of feedback loops in neuronal time scales.

3. In REM dream virtual sensory input dominates. Interpretation for imagination as virtual sensory input stopping at some higher level than sensory organs.

4. Nerve pulse patterns affect dramatically membrane potential and make possible communications from the brain to the "large" layers of MB and fractal hierarchy of analogs of EEG can be considered. Axons act as generalized Josephson junctions generating dark Josephson radiation travelling to the "large" layers of MB. Frequency modulation of Josephson frequencies codes for sensory input represented by nerve pulses.

3.2 Two aspects of cognition

3.2.1 Linear, reductionistic, and time-local aspects of cognition

The neural transmitters promote in the healthy brain the formation of memories understood as neural level behaviors basically by allowing to connect axons temporarily to longer linear neuronal structures: Hebb's rules (`https://cutt.ly/os4ckD9`) characterize this dynamics. This would be the role of the information molecules quite generally.

The key topological observation is that only a single axon emanates from a given neuron. It can however branch so that several neurons can receive the nerve pulse signal from a given neuron so that the network is not tree-like - neither fully linear nor fully non-linear. Also loops are possible.

Tree-likeness means that if an axon becomes dysfunctional, neural signals do not propagate further. This could happen in AD. Nerve pulse conduction fails also if Ach or other needed neural transmitters are not available so that nerve pulses are not mediated over synaptic clefts. The failure of linguistic consciousness in AD [Kempler and Goral 2008] motivates the hypothesis that neuronal level is responsible for this mode of consciousness.

3.2.2 Spatial and holistic aspects of cognition

Cognition has besides the linear and temporal linguistic aspects assignable to neural activity - also spatial and holistic aspect.

1. The TGD based vision about MB is as a fractal structure having besides the "large" part also "small" parts in the scale of body and brain. This vision predicts that neurons appear as nodes of magnetic flux tube networks, which can be 2- or even 3-D. Part of these flux tubes can be parallel to axons. These magnetic flux tube networks could relate to the holistic, geometric aspects of cognition. If these flux tubes carry monopole flux, they are stable against splitting. Therefore episodic memories assignable to these networks would be stable.

   More probably, the flux tubes are closed looking like very long and narrow parallelograms connecting two systems. These flux tubes could split by reconnection to two pieces forming smaller long parallelograms. These networks could be rather permanent at the scale of the body, and also these networks could have nodes where reconnections can occur. Psychoactive drugs could induce this kind of reconnections over very long distances [Pitkänen 2015b]. In particular, to the large part of personal MB.

2. In music experience these two aspects combine: rhythm corresponds to the time-local, linear aspect and harmony to the holistic aspect [Sacks 2011]. It is quite possible that the neural system alone cannot represent the latter aspect. This suggests that neurons - or perhaps glial cells - form 2- or 3-D networks connected by the analogs of axons identifiable as flux tubes in TGD framework [Pitkänen 2014a, Pitkänen 2016, Pitkänen 2017a]. Also the meridian system postulated by eastern medicine could relate to this. This system would precede the nervous system and even plants could have it.

   These 2- or 3-D structures are stable against the splitting of axon-like units so that the holistic aspects of cognition would be preserved in AD. The AD patient can indeed understand the words of songs. The signaling in this system would take place

by dark photons with non-standard value $h_{eff} = nh_0$ of effective Planck constant, which are photon-like particles transforming to biophotons [Pitkänen 2013c].

3. The vision about the brain based on the theory of consciousness and living systems [Pitkänen 2014a, Pitkänen 2020b] inspired by Topological Geometrodynamics [Pitkänen 2016, Pitkänen 2017a, Pitkänen 2017d] leads to the view that also neural system uses dark photons to the communications in brain. The function of nerve pulse activity would be to build communication lines by combining the magnetic flux tubes accompanying axons to longer structures serving as analogs of wave guides along which dark photons can propagate [Pitkänen 2018a, Pitkänen 2018d]. The information molecule would play the role of a relay element. The analogy with modern electronic communications is obvious.

   The evolutionary reasons could be the reduction of metabolic costs and the advantages due to the ability to rapidly modify the topology of the flux tube network. For instance, flux tube structure would make possible topological quantum computation based on the braiding of the flux tubes [Pitkänen 2006d, Pitkänen 2006e].

4. TGD leads to a model of genetic code based on the notion of bio-harmony inspired by the attempt to understand the notion of musical harmony. The model relies on the realization of harmony as collection of allowed 3-chords realized in terms of frequency triplets. It turns out that the representation in terms of icosahedral and tetrahedral geometries leads to a large number of harmonies allowing representation of vertebrate genetic code [Pitkänen 2014b, Pitkänen 2014c, Pitkänen 2019a]. Since music creates and expresses emotions, the interpretation is that these bio-harmonies represent emotional states, moods [Pitkänen 2018d, Pitkänen 2018e]. Bio-harmony would represent collective aspects of cognition, emotional intelligence whereas neural activity would represent its time-local and linear aspects.

5. Idiot savants are capable of amazing memory feats [Treffert 1988]. For instance, they can play an entire music piece having heard it just once or draw an entire landscape from memory. This strongly suggests that holistic memories are indeed subjective- re-experiences rather than learned behaviors. Idiot savant would see the landscape that he is drawing. These memories are also holistic, which suggests that subjective memories are assignable to the 2-/3-D magnetic flux tube networks rather than basically linear neural networks.

   Could brain chemistry provide tools - say various psychoactive drugs - promoting holistic cognition [Pitkänen 2015b]. N,N-dimethyltryptamine (DMT) - a psychoactive compound produced by the brain itself - is what comes first in mind [Pitkänen 2018a]. Idiot savants have severe cognitive defects but are able to perform miraculous feats related to memory, mathematics, and arts. Could holistic cognition replace neural linear cognition in these situations?

3.2.3 Are holistic and geometric aspect of cognition associated with meridian system or glial system?

MB would give rise to a flux tube network with flux tubes connecting basic units which could be neurons but possibly (also) glial cells. This network would be also fractal appearing in various scales. Axonal network would be only part of this network with axons accompanying flux tubes forming a sub-network with the property that from a given node only a single axonal flux tube emerges which possibly branches later. There is however no reason to assume that the number of flux tubes emerging from a given node is only one. Also flux tubes without accompanying axons are possible.

Therefore non-dynamical 2- or even 3-D magnetic flux tube networks are also possible but not as neural systems. The attractive identification is as correlates of 2- or even 3-D holistic consciousness. Dark photon signals can propagate also along these networks. Key feature is the stability against splitting of a single flux tube distinguishing these systems from 1-D linear systems. If neural transmitters serve as relays connecting flux tubes to longer units for axonal pathways, a subset of information molecules such as DMT could also act in the similar manner in the entire flux tube network.

1. Could holistic aspects correspond to the meridian system with meridians associated with flux tubes and acu points acting as nodes? This kind of networks could be possessed also by invertebrates such as plants. Could glial cells form nodes of this kind of network? Could glial *resp.* neuronal systems forming a coupled pair be responsible for holistic and spatial *resp.* reductionistic, time-local, and linear aspects of consciousness.

2. Is there a connection with AD? Linear language based consciousness associated with nerve pulse activity would degenerate in AD since the axons with plaque would not conduct nerve pulses and the formation of temporary signal networks would fail. The 2- or 3 D holistic consciousness stable under this kind of splitting would however remain [Pitkänen 2018b].

3. What is the relationship to the right-left dichotomy often assigned with the holistic-reductionistic dichotomy? It is said that the left brain talks and he right brain sings. AD patients understand words, which are sung. How strictly this is true? Should R-L dichotomy be replaced with neural-meridian or neural-glial dichotomy as a realization of holistic-reductionistic dichotomy.

3.2.4 Sleep *resp.* awake as holistic consciousness *resp.* linguistic consciousness?

How the two kinds of consciousness relate to time reversal and left-right division of the brain?

1. Neuronal consciousness dominates during wake-up but during sleep neural activity is suppressed by hyperpolarization. Sleep could therefore correspond to the dominance holistic, spatial consciousness assignable to the meridian system or glial system.

2. What about the arrow of time for the consciousness during sleep (about which we - at least apparently - would not remember anything). Could the MB for the meridian-/glial system have reversed arrow of time during sleep and have sensory input from the geometric future? This could explain precognitions and prophecies.

3. One can also ask whether right- and left hemispheres have opposite arrows of time in time scales longer than nerve pulse duration T. This is not possible in the axonal length scale since axonal potential would change its sign in times scales longer than T.

How these two modes of consciousness relate to EEG and electric fields of brain and body.

1. Cyclotron frequencies characterizes the flux tubes. Time reversed part of MB in scales corresponding to "us" does not contribute to "our" consciousness during wake up. We do not remember anything about the sleep period without dreams: could it be that "we" are in time reversed mode so that there are no memories about this time.

   During sleep $f < 10$ Hz dominates in EEG: it does not correlate with "wake-up" consciousness. Could sleep correspond to holistic time reversed consciousness with reduced neural activity (by hyper-polarization) perhaps assignable to meridian or glial network. During wake-up $f \geq 10$ Hz dominates and correlates with the contents of consciousness. Linear neural consciousness would dominate.

2. How the time reversal reflects itself in EEG? There are indications that EEG consists of slices of duration about 300 ms decomposing to order and chaotic pieces [Fingelkurts et al 2013] [Pitkänen 2013a]. Could these pieces correspond to dissipation in standard arrow of time and with opposite arrow meaning effective generation of order?

3. What about longer spatial and time scales? Could the change of the arrow of time show itself somehow. The direction of velocity and electric field changes opposite in time reversal. Could the propagation direction of say thalamo-cortical EEG waves with 40 Hz resonance frequency in the cortex change. 40 Hz resonance occurs also in the transition to meditative state. What could this mean?

   It is known [Becker 1990, Becker 1990] that the change of the direction of the electric field along the body axis leads to a loss of consciousness (for TGD based model for the direct currents of Becker see [Pitkänen 2012]): could this mean actually the change of the arrow of time at the layer of MB controlling the dynamics in this

length scale. Same is true concerning the reversal of electric field from frontal lobes to hindbrain. Longitudinal electric fields are also associated with microtubuli and DNA.

Also oscillating electric fields are important in living matter.

1. By Faraday's law oscillating electric fields also accompany oscillating magnetic fields and could generate bio-rhythms as repeating cycles living-alive-living-alive or ..-wake-up-asleep–wake-asleep.. . Cyclotron frequencies, generalized Josephson frequencies, and Schumann resonance frequencies would define various bio-rhythms forcing biochemical rhythms. Rhythm of breathing and of heartbeat would be examples of such bio-rhythms. Also EEG rhythms would define life-death cycles. For instance, EEG decomposes to pieces with duration of 300 ms having this kind of structure [Fingelkurts et al 2013, Pitkänen 2013a].

   Both quasi-static and oscillating longitudinal electric fields accompany microtubules [Pokorny et al 1998]. Ghosh et al [Ghosh et al 2014] have found that oscillating electric fields along microtubuli can generate longitudinal ballistic currents (perhaps supra currents) along them at certain critical frequencies: the results are discussed from the TGD perspective in [Pitkänen 2014d].

2. There is evidence for the healing of cancer by using an extremely weak oscillating magnetic (and thus also electric) field in nanotesla range with frequency of 60 Hz, which is a Schumann resonance frequency [L and Heroux 2014]. The TGD inspired model for the finding [Flavin and Pitkänen 2018] missed the interpretation as a re-establishment of a lost life cycle.

4 Brain science and recalling memories of future

The notion of memory must be defined more precisely first.

1. In neuroscience memory is defined essentially as a learned behavior and reduces to the change of synaptic connections. The episodic and sensory memories are not like this: they are genuine re-experiences. Idiot savants would have this kind of sensory memories. For instance, they can play an entire music piece or draw an entire landscape from memory such that all details come out correctly. Idiot savant sees again the landscape that he is drawing. Neuroscience cannot provide a convincing explanation for these memories, which suggests that something very important is missing from the picture.

2. Subjective memories predicted by the TGD framework are different from learned behaviors. They are indeed genuine re-experiences - direct sensory experiences or symbolic representations of sensory mental images involved. They do not involve

the emergence of new behavior or new associations by strengthening of synapses. They would be essentially at the level of the MB and perhaps predecessors of the memories as identified by neuro-scientists.

4.1 What memories of the future could mean?

What the memories of the future could mean?

1. In TGD framework subjective precognition is not possible since the subjective future does not yet exist: moment of consciousness corresponds to a re-creation of the quantum sub-Universe as zero energy state.

2. In TGD Universe geometric precognition is in principle possible and corresponds to a receival of objective information - physical signals - from the geometric future and might occur routinely. My subselves (mental images) with an opposite arrow of time can represent geometric memories from my geometric past. Precognition as a recall of future geometric memories would rely on sensory perception with an opposite arrow of time by some subselves assignable to the structures of the brain. The arrow of time would be reversed at some layer of MB and induce effective change of arrow at the level of ordinary biomatter in longer time scales than usual.

   Remark: At molecular level BSFRs occur very frequently so that the period with fixed arrow of time is very short.

3. Neuroscientists usually interpret memories as learned associations assignable basically to the strengthening of synaptic contacts (Hebb's rules, `https://cutt.ly/os4ckD9`). These memories are like a text carved to stone and should be distinguished from genuine subjective memories. The sensory inputs from the geometric past and perhaps even from geometric future could induce memories in this sense.

   The interesting question is what the change of the arrow of time could mean at the level of nerve pulse conduction. Axons realize the arrow of time as a fixed direction of neural conduction. MB in time reversed mode changes effectively the arrow of time as the level of ordinary matter in long length scales. Does this mean that nerve pulses travel in an opposite direction than usual?

   This has also interesting connection with AD [Bredesen 2017] discussed from the TGD point of view in [Pitkänen 2018b]: the approximately exponential attenuation of signals along axon with plaque would look like exponential amplification in the standard time direction, and the neural signalling with reverse arrow time might be possible! In the TGD framework death would be a universal phenomenon and mean re-incarnation with a reversed arrow of time. In AD death would have already started at the neural level. What would be conforting that death would be accompanied by a re-incarnation.

4. There is an objection against the change of the arrow of time at the level of axons. The behavior of electric field in time reversal suggests that the sign of membrane polarization should change in the time reversal. Time reversal occurs during nerve pulses if they involve BSFR. For the time reversed states the periods of pulse-on and pulse-off would be permuted so that the effect might not be very dramatic during firing. In the absence of firing the sign of membrane potential would be opposite and this cannot occur in long time scales.

   The duration of the nerve pulse varies from $T_1 = 1$ ms (sodium based action potential) to about $T_2 = 100$ ms (time scale for sensory mental images!) for Calcium based action potentials and can be understood as being due to BSFRs. One could argue that T_2 corresponds to the maximal duration of the time reversal in the axonal length scale. In longer length scales the time reversal periods could be longer and manifest themselves in different manner such as a change of the direction of conduction velocity.

   Since the time scale T and size scale L for any CD are related by $L = cT$, the change of the arrow of time at brain level during sleep should occur in a considerably longer time scale. The ratio of the time scale of sleep period taken for definiteness to be $T = 6$ hours to $T_1 = 1$ milliseconds is $r = T/T_1 \simeq 2 \times 10^7$. What is the length scale L assignable to T. If the length scales assignable to axonal conduction is cell membrane thickness $L_1 = 10^{-8}$ m, ab one has $L/L_1 = T/T_1 = r$, one has $L \sim .2$ m not far from the size scale of the brain.

   A good guess is that the spatial scale associated with $T_2 = 100T_1 = 100$ ms (no sensory mental images during sleep) is given by $(T_2/T_1)L_1 = 100L_1 \sim 1\mu$m and is thus the length assignable to cell nucleus. For the same value of the scaling factor r, this would give $L \sim 20$ m, longer than the length scale of the human body but roughly consistent with the size scale of largest animals.

4.2 Are memories of the future possible in some sense?

Dr. Reza Rastmanesh asked in personal communications whether the Acetylsalicylic esterase (AChE) inhibitors could promote the formation of memories in the reverse time direction - to precognize in some sense. The mainstream view of neuroscience does not distinguish between future and past memories at fundamental level and the asymmetry can be understood only in terms of thermodynamics postulating a fixed arrow of time.

In TGD framework one can speak about precognition of geometric future - sensory experiences about geometric future possible for time reversed conscious entities with time reversal taking place at the level of MB. Conscious entities cannot have direct subjective memories of the future since subjective future does not exist. If the MB of the sleeping brain has a non-standard arrow of time, its partial wake-up could give rise to a dream, which can but need not be precognitive.

4.2.1 Two proposals for understanding memories of future

The level of the transcription factor cAMP/Ca(2^+)-response element binding protein (CREB) is a key factor governing which neurons are recruited for a given memory trace [Kim et al 2007]. Recently a similar role has been proposed for cGMP response element binding (GREB) protein. Inhibition of phosphodiesterase 5 restored cognitive function in scopolamine-induced amnesia mice by activating the cGMP/CREB signaling pathway and attenuating oxidative stress [Zhang et al 2018], with promising implications for treatment of AD. Collectively, in addition to cAMP, cGMP and Amyloid β has been proposed as critically important for memory formation [Ricciarelli and Fedele 2018].

CREB is a ubiquitously expressed transcription factor expressed in the brain. It regulates neuroplasticity by modulating gene expression [Lee et al 2005], and so loss or dysfunction in CREB is lethal (at least in mice, and presumably embryonically lethal also in humans), and it may not be feasible to modulate CREB in interventional clinical trials. Down-regulation of AChE in the brain [Perry et al 2004] has been considered as the most important pathway by which CREB modulates memory allocation.

It has been argued that we do have memories of the future; we just cannot make sense of them [Watt et al 2015]. In the framework of behavioristic neuroscience, one can ask whether the factors such as CREB, GREB and Amyloid βthat enable to memorize the past, meanwhile prevent disable from remembering the future. They would select the arrow of time. Note however that these factors relate to memories interpreted as learned behaviors and it is far from clear that episodic memories are such. In any case, the sensory input from the geometric future can also modify synaptic strengths.

There are two options to consider.

Option I: Suppose that also episodic memories reduce to the synaptic strengths as in behavioral approach. Since Ach plays a major role in the formation of memories in this sense [Haam and Yakel 2017], further information about the relationship between AD with memory and precognition would be essential to design a novel and innovative technology to remember the future using specific agents selectively targeting the neural transcription factors or neurotransmitters involved in memory formation. There are numerous factors involved in the memory formation, consolidation and transformation [Nadel et al 2012], however, because of its central role, the focus will be on Ach and AChE in this paper, for convenience.

Option II: In the picture based on ZEO the MB carrying dark matter bio-chemistry are in a master-slave relationship. The arrow of time is changed in BSFR at the level of MB and induces its effective change at the level of ordinary matter. The most natural reason for BSFR would be however the depletion of metabolic energy sources: during time reversed phase the subself would be able to extract energy from the environment. For this option the technology to remember the future could be rather brutal: a down-regulation of metabolic energy feed! One can however ask whether MB as the wise boss reacts to the pressures from the lower level and for critical concentrations of neural transmitters makes a BSFR changing the arrow of time.

4.3 Future perspective assuming Option I

It remains to be determined whether our inability to remember the future is a biologic limitation or a physics limitation, but it is scientifically testable. In other words, the ability or disability to re-member the future with this perspective is mostly a matter of information sufficiency or deficiency, respectively, or biologic limitation rather than a limitation imposed by physics. The hypothesis will find enormous technological applications if proves to be true. If there are no means for humans to predict the detailed future of the world, it is not because of physics per se; rather it might be because of information deficiency. Below, we propose two thought experiments to investigate a priori hypothesis

Increased precognitive dreaming following administration of AChE inhibitor (Rivastigmine) in AD patients has been reported before by de Pablos [de Pablos 2002, de Pablos 2005]; however this has not been replicated by other researchers. To investigate the correlation between AChEIs and precognitive dreaming entails meta-analyzing results on experimental dream-ESP studies carried out before.

4.3.1 Retrospective design

Independent Data sets about dream-ESP (if there are any) from previous trials that have administered AChEIs to AD patients be re-analyzed retrospectively to attempt to find out any effect from AChEIs on precognitive dreaming. Dream-ESP is defined as a form of extra-sensory perception (ESP) in which a dreaming perceiver seemingly gains information about a randomly selected target without using the logical inference or normal sensory modalities, as described before [Storm et al 2017].

According to the procedure described by Strom et al [Storm et al 2017], studies can be categorized into two categories: the Maimonides Dream Lab (MDL) studies, and independent (non-MDL) studies. Mean ES for both MDL dataset and the non-MDL studies should be calculated in order to find a significant or meaningful difference between the two mean values. Using a homogeneous dataset with a sufficient sample size, it is possible to yield a mean z, with corresponding Stouffer Z, to elucidate whether dream content can be used to identify target materials correctly and more often than would be expected by chance. Also, any significant differences between: (i) three modes of ESP (telepathy, clairvoyance, precognition), (ii) senders, (iii) perceivers, or (iv) REM/non-REM monitoring can be measured. For details of the protocol see [Storm et al 2017].

We suggest that trials investigating AChEIs in AD patients, measure appropriate variables such as alterations in sleep architecture, EEG power spectral analysis, and quantitative EEG of rapid-eye-movement sleep to yield preliminary data for future double blinded clinical trials. Retrospective design cannot be used for investigation of causality.

4.3.2 Controlled design

In a double-blind, placebo-controlled, randomized, study, sufficient sample sizes of patients with mild to moderate AD who are taking stable doses of AChEIs will be enrolled.

Within 28 days prior to study drug administration, patients will be screened based on National Institute of Neurological and Communicative Disorders and Stroke/Alzheimer's Disease and Related Disorders Association (NINCDS/ADRDA) criteria with attention to revisits [Kim et al 2007] for probable AD, Mini-Mental State Examination (MMSE) and Modified Hachinski Ischemic Scale (MHIS) scores, medical history, physical examination, neurological examination, vital signs, ECG, laboratory tests and response to Columbia-Suicide Severity Rating Scale (C-SSRS).

Participants will be administered standard precognitive dreaming questionnaires and will be invited to a sleep laboratory. Patients will be asked to dream about a target video they would later view. A blinded judge would rate patients' dreams against the target and decoys. Evidence for dream precognition will be recorded. The study can be accomplished with testing the hypothesis that precognitive dream experiences may occur when an AD patient subconsciously incorporates sensory information into their dream. A sound clip would be played to sleeping patients and a blinded judge would rate the target and decoy clips against the patients' dream transcripts. The correlation between degree of sensory incorporation and prior precognitive dream experience will be measured, as described before [Watt et al 2015].

We suggest that a combined controlled sleep laboratory study and EEG or event-related potential (ERP) indices would be instrumental in AD patients who are taking AChEIs compared with that of AD patients who are taking placebo to find out any effect of AChEIs on EEG and ERP and precognitive dreaming and a possible causal correlation between EEGs and precognitive dreaming and dream content. Cortical AChE activity will be measured in both groups and spearman correlation coefficient will be calculated between the cortical AChE, AChEI and Ach concentrations with dream content/precognitive dreaming.

Also, to test the hypothesis, it would be also useful to investigate whether AD patients who score lower on a Wechsler Memory ScaleIII [Seelye et al 2009], are more likely to have a higher report of precognitive dreaming. This is especially important in the case that AD patients *premember* an event, but cannot *remember* to report that event.

4.4 An attempt to relate Option II to biochemistry

The following arguments suggest that the findings about AD patients are consistent with Option II based on ZEO.

4.4.1 Consistency with the findings about AD patients

The following represents an attempt to understand these effects assuming **Option II** that is ZEO.

1. Acetylcholine (ACh) is a neutral transmitter involved with synaptic transitions and important for the formation of memories understood as learned associations and

behaviors to be distinguished from genuine subjective memories. In TGD framework ACh promotes in a healthy brain the formation of memories basically by allowing connect axonal flux tubes temporarily to longer linear structures so that associations can form.

If the postsynaptic axon becomes dysfunctional neural processing partially fails: this is like cutting a linear chain. This could happen in AD [Bredesen 2017, Pitkänen 2018b]. Nerve pulse conduction fails also if Ach is not available so that nerve pulses are not mediated over the synaptic clefts and formation of signal pathways for dark photons signals is prevented.

2. AChE promotes the decay of ACh so that it stays for a shorter time period in the synaptic contact. AChE inhibitor (AChEI) causes an opposite effect. The longer ACh lifetime is in turn expected to promote the formation of short term memories in the behavioristic sense via stronger synaptic strengths and would thus help in AD. This is true if the postsynaptic axon conducts nerve pulses. But doesn't plaque formation effectively cut the axon so that the strengthening of the synaptic connection is useless in AD?

3. If linear memories do not survive in AD due to the failure of nerve pulse conduction along the postsynaptic axons, their formation is a waste of the metabolic energy. If this is prevented, the metabolic energy could be used to form non-linear and holistic right-brain memories as 2- or 3-D structures. These memories would be subjective mental images rather than behaviors. The system behind holistic cognition might come in rescue.

4. Consider now the question of Dr. Reza Rastmanesh. It would seem that AChE could promote the transition to the mode in which holistic subjective memories dominate by shortening the life-times of ACh molecules. Even the reduction of ACh level could favor holistic cognition since ACh is useless if the postsynaptic axons are dysfunctional. AChE inhibitors would favor synaptic transmission but in AD this would not help if axon is not able to conduct. Is the transition to a holistic mood the optimal response?

   But if the memories are subjective in this case, it would seem that precognition is not possible - contrary to the reported evidence including prophetic dreams!

5. This paradox disappears if the change of the arrow of time means change of the direction of nerve pulse conduction. The approximately exponential attenuation of signals along an axon with plaques would look like exponential amplification in the standard time direction, and the nerve pulse conduction could be possible! Also now neural transmitters would be needed in the synaptic transmission to connect the flux tubes to longer units.

4.4.2 Precognitive dreams as communications of episodic memories between conscious entities having different arrows of time?

The precognitive dreams suggest also the subjective memories of future or their analogs are possible. Self as a conscious entity can have only memories of previous experiences of subjective past and direct episodic memories of future are not possible since it does not yet exist for self.

One could perhaps overcome this restriction. Suppose that the MB of the sleeping brain has a non-standard arrow of time. Dreams could correspond to the wake-up of some part of the MB of the sleeping brain by BSFR. It would have the standard arrow of time and would contain information about the sensory mental images of the sleeping brain. Could this information be experienced as a dream? Not all dreams need be precognitive since the sensory input from geometric could come only from the interior of the CD of the sleeping brain.

5 Appendix: FQA related to the possibility of the memories of future

In the following we will propose possible answers to some questions posed during the collaboration by Dr. Reza Rastmanesh related to the proposal that memories of the future might be possible as memories in the behavioristic sense and being induced by the non-standard arrow of time at the MB of the system.

5.1 General questions

Q1: Can we have a thought experiment, by which one can prove the occurrence of time reversal in the human brain?

A1: ZEO implying both arrows of time can be justified by a simple thought experiment. Ordinary thermodynamics with a single arrow of time predicts heat death of the Universe since the energy flows between systems making self-organization possible die away by the second law of thermodynamics. Life must be regarded as a thermo-dynamical fluctuation - and as it seems in cosmological scales and even characterized by evolution. This is nonsensical.

Q2: Most skeptics urge that precognition is not possible, could one propose some techniques by which other researchers amend or correct their methodology.

A2: I do not believe that proving is possible since all depends on fundamental assumptions. Experimental testing is however possible.

1. The direction for the nerve pulse conduction would change *if the arrow of time is effectively reversed for axons that in length scales about the length of or thickness of*

the axon. This is a rather dramatic prediction and could explain the claimed phenomena like reverse writing [Lambon-Ralph et al 1997] and reverse speech (`http://www.reversespeech.com/words.shtml`) discussed from the TGD point of view in [Pitkänen 2006a].

I remember an article that I read a couple years ago telling that recalled episodic memories have order opposite to that for the actual events. This supports the TGD view about active memory recall.

Remark: Real time reversal would occur only at some layer of MB and induce an effective time reversal in shorter time scales.

2. Second prediction is that axonal potential could change sign in the effective time reversal *if it occurs in the length scale defined by the thickness of axonal membrane different from axonal length*. This kind of change of arrow of time would place also for ordinary nerve pulses so that the roles of no-pulse and pulse periods would change. This would occur for ordinary nerve pulse transition in the time scale of nerve pulse varying from ms to 100 ms but not longer scales.

Q3: What is the most pronounced weakness of current methodologies which fail to detect or recognize the phenomenon of bilateral time arrow in the human brain? Is it just our ontology and epistemology which is uni-biased over time and history? Is it because of our language which prohibits a bilateral arrow of time?

A3: The fundamental weaknesses are in the basic ontology, which postulates a fixed arrow of time already at the level of physics. Science relies on language and this might partially explain even this postulate although there is experimental evidence supporting the possibility of a non-constant arrow of time.

The basic problems of also modern physics are due to the obviously wrong (to my view) philosophical dogmas. For instance, memories are defined as changes of behavior and reduced to changes of synaptic contacts. This has nothing to do with episodic memories, memories as re-experiences about which idiot savants are an excellent example.

Q4: Why dont we realize that we have precognition?

A4: One can imagine several reasons.

1. Precognition is quite too familiar. We can predict quite well what we will do tomorrow and what the world will look like tomorrow. This is regarded as totally trivial or as an outcome of computations in the brain. It would be interesting to look whether AI can do this precognition easily.

2. Second reason is that we do not remember anything about periods with a reversed arrow of time. Sleep could be such a period and the only memories are from the state in which some brain regions have standard arrow and remaining still the reversed arrow.

3. The time reversed sensory perception would in the TGD picture give rise to memory in behaviouristic sense - not episodic memories. This would mean that synaptic strengths would change and change our behaviour. This change is not manifest to us!

Q5: Isnt that partially because our evolutionary biology dictated such a unilateral time arrow?

A5: Here I disagree. I understand with "unilateral" that the arrow of time is fixed and always same for both hemispheres always.

1. In TGD framework The period for a fixed arrow of time in atomic scales changes is very short: the average time duration between two ordinary state function reductions, lifetime of self in the atomic scale. This continual living and dying actually gives rise to thermalization.

2. Dark matter as $h_{eff} = nh_0 > h$ phases at MB makes possible much longer time scales with fixed arrow of time and conscious entities can have long lifetimes. The lifetime depends on the level of the self hierarchy. At brain level it could be perhaps 6 hours - of the order of wake-up - or sleep period. At he higher levels of the self hierarchy it could be longer, say human life-time. At axonal level it corresponds to the duration of the nerve pulse between 1 ms and 100 ms etc.. ZEO - that is geometry of CD- allows to expect that the length scale L and time scale T of self are related by $L = cT$.

Q6: What are the possible benefits of an unilateral time arrow? Is there any way for acquisition of such experiences?

A6: I can answer to a question with "unilateral" replaced with "bilateral" meaning that brain hemispheres can have different arrows of time. Even more generally, subsystems of brain can have varying arrow of time. Suppose the system consists of a pair for which magnetic bodies live in opposite arrows of time at some level of self hierarchy - say brain hemispheres. This would make the system able to have geometric memories (sensory perceptions) of both past and future. Anticipation of the future would become possible besides memory and this would certainly be an evolutionary advantage. This prediction does not look so dramatic, when one realizes these memories would be memories in behavioristic sense: changes in the synaptic strengths.

Q7: For example, using EEG we can record the frequencies of the brain, is there any technological possibility by which in future humans can differentiate between forward arrow of time and backward arrow of time?

A7: Long time ago, I [Pitkänen] had long discussions with two neuroscientists - brothers Fingelkurts - living in Finland. They had observed that the EEG decomposes to segments of about 300 ms [Fingelkurts et al 2013] [Fingelkurts et al 2013]. The segments seem to have division to order and chaotic pieces. A possible interpretation would be that

chaotic piece corresponds to ordinary arrow of time with dissipation causing the chaos and the order piece to opposite arrow of time in which dissipation looks like generation of coherence and order for a human observer.

Q8: Option II states that in the wake-up state with standard arrow of time we don't remember the future in the sense of having sensory input from it, but what about our working memory capacity and confabulation? One may argue that we may not remember the future in detail; another person may argue that this is partly because of amnesia. For example, we cannot remember the past as well, even though we have physically experienced it. We forget some true memories and experiences related to the past, we add some fake memories or experiences which never happened, we confabulate some memories that never happened, etc. The fact that we cannot remember the future, in addition to any biological advantage, maybe is partly because of limitation in our working memory capacity. In fact, there is evidence that during sleeping state, working memory is lower compared to that of wake up state [Reichert et al 2016], and working memory span is restricted during sleep state compared to that of wakefulness [Conway et al 2005]. There are also inter-individual differences for example, in terms of genetic polymorphisms [Reichert et al 2005], age [Sculling and Bliwise 2015] or time of day [Wyatt et al 2004] from the stand point of working memory. These seemingly minor variables may partially explain why some studies of testing the implicit processing hypothesis of precognitive dream experiments have failed before [Valasek et al 2014]. Therefore, close attention to hidden variables is necessary when designing clinical trials to test precognitive effect of any potential specific agents selectively targeting neurotransmitters involved in memory formation during sleep state.

A8: In the TGD framework there are two fundamental reasons for not seeing the future in detail.

1. Zero energy state as a superposition of space-time evolutions changes all the time, in each quantum jump. There is no unique objective reality nor future in classical sense. Only the changing superposition. The prediction of future given by sensory perception with a reversed arrow of time is only a prediction: it holds true only if now further acts of free will re-creating the world or part of it in 4-D sense do not occur.

2. Finite measurement resolution is the key element of adelic approach. The positive aspect of finite cognitive resolution is that it prevents us from drowning to information and selects the most important digits. This notion has been accepted in theoretical physics but its mathematical description is primitive. In TGD adelic physics leads to a unique discretisation of space-time surface for the given evolutionary level characterised by an extension of rationals. The higher the level, the better the resolution of cognition and sensory perception.

Concerning the amnesia hypothesis.

1. We would not have episodic memories - re-experiences - at all in reverse time direction. Subjective future does not yet exist.

2. We can have sensory percents of geometric future. They are not episodic memories.These would affect the synaptic contacts and change our behaviours: it is not easy to see changes in one's behavior and even more difficult to assign them to time reversed sensory perception! But of course, our future expectations - precognition - can dramatically affect our behavior!

About confabulation I can only propose what it correponds in the TGD framework.

1. Confabulation is an interesting phenomenon closely related to imagination. Adelic and p-adic physics can be seen as an attempt to identify physical correlates of imagination, which is indeed confabulation in some sense . p-Adic variants of space-time surfaces are not completely deterministic and could be seen as correlates of imagination of confabulation.

   In general the -adic space-time surfaces can only partially correspond to real space-time surfaces since for the latter the determinism is complete. Imaginations could correspond to p-adic space-time surfaces having only partially real counterparts. Say those representing dark photon signals from he brain or even from the MB to the sensory organ and generating virtual sensory input during REM, hallucinations, or psychedelic experiences.

2. In the case of imagination they would never reach the sensory organs and would not give sensory input. Same is true for motor actions: motor commands do not reach muscles during dreams. Imaginations are almost sensory experiences and almost motor actions. Sensory input strongly bounds imagination and confabulation: in think tanks the constraints are absent and the person starts to hallucinate.

Q9: Can you add some applications?
A9: Electric fields populate living systems. Both static and oscillating electric and magnetic fields are abundant in living matter. Becker [Becker 1990, Becker 1990] was one of the first researchers to realize their role for life. If the sign of an endogenous electric field assignable to organelle changes as the arrow of time changes for the corresponding layer of MB, its change might force time reversal. Oscillating electric fields would estabish bio-rhythms as life-death cycles. This suggests quite science-fictive sounding applications.

1. Healing by rejuvenation could be one application. Becker et al found that in the cleft between wound tissue and CNS and electric potential having a sign opposite to that in the normal situation develops, and after the healing has occurred, the normal voltage is re-established [Becker 1990, Becker 1990]. Note that nerve pulse is in certain sense a wound but in a shorter scale.

Could this mean that the layer of MB associated with the wound region makes a BSFR - dies and reincarnates with an opposite arrow of time - and eventually returns to the healthy state by a BSFR? If so, external electric fields changing the sign of the appropriate voltage might be used for healing purposes [Pitkänen 2012].

2. Healing by re-establishment of lost bio-rhythms could be a second application using oscillating external electric field or magnetic field accompanied automatically by electric field. Year ago we wrote with Dana Flavin an article [Flavin and Pitkänen 2018] about the evidence for a healing of cancer by using an extremely weak oscillating magnetic (and thus also electric) field in nanotesla range with frequency of 60 Hz, a Schumann resonance frequency but did not realize this interpretation [L and Heroux 2014]. The interpretation could be as a re-establishment of a lost life cycle.

3. Also the production of germ cells from highly differentiated cells could be based on the time reversal and electric fields might be used to return the diseased cell population to its earlier state: somewhat like returning the computer to its earlier stage when some problem occurs.

4. Chemists Guido Ebner and Heinz Schuerch [Internet URL 2020] have studied the growth and morphogenesis of various organisms in presence of electric fields. Germ, seeds, or eggs were placed between conducting plates creating an electric field in the range .5-2 kV/m: note that the Earth's electric field is in the range $.1 - 4$ kV/m and of the same order of magnitude. The outcome was rather surprising and in the year 1989 their employer Ciba Geigy applied for a patent "Method of enhanced fish breeding" for what is called Ciba Geigy effect. The researchers describe how fishes (trouts) develop and grow much better, if their eggs have been conditioned in an electrostatic field. The researchers also reported that the morphology of the fishes was altered to what seems to represent an ancient evolutionary form: this was not mentioned in the patent.

   The explanation discussed in [Pitkänen 2012] would be that the DNA serves as a kind of evolutionary archive realizing "ontogeny recapitulates phylogeny" very concretely. The presence of the electric field would stop the phylogeny by allowing the expression of an older variant of the genome. A more abstract realization would be that the genome experiences phylogeny during ontogeny. The application of an electric field with a proper sign and magnitude could stop the ontogeny to an earlier stage.

   One could even imagine changing the arrow of geometric time and producing earlier evolutionary variants of a simple organism or organelle by using electric field: the strength of the electric field needed might relate to that prevailed during the earlier evolutionary stage.

Second application could be a creation of artificial life. Also the relationship to AI is highly interesting. Electronic circuits involve both energy feed as a counterpart of metabolic energy feed, they involve electric and magnetic fields, and also resonance frequencies. This makes self-organization possible and even a self-sustaining situation in which the system experiences a sequence of life-death cycles can be considered.

1. The findings about simple systems having life-like properties involve typically an oscillating electric or magnetic field. One such system consists of plastic balls [Gogia and Burton 2017]: the TGD inspired model for the system is discussed in [Pitkänen 2017c].

2. It would be interesting to arrange a coupling to the MB of Earth by using Schumann resonance frequencies and by the cyclotron frequencies in endogenous magnetic field $B_{end} = 2/5B_E$ explaining the findings of Blackman and others [Blackman 1994] (B_E denotes Earth's magnetic field) so that the MB of Earth could become the boss. Plasma structures would be also ideal candidates for living systems and bio-matter is indeed a cold plasma. Ball lightning would be one example about a plasmoid as a primitive life-form.

3. The manipulation of bits induces changes of the electric and magnetic fields and there are oscillating electric fields present such as the computer clock. If MB is involved actively, this could give rise to a living system having even its own intentions and free will. Note however that the MB in questions would be most naturally that of the user! Can one build a computer whose personal MB takes the lead? It might be that the computer is living in some sense which is even related to the program running in it.

5.2 More questions about the arrow of time

Q1: We have to mention energy cost of memory, in its broad meaning (either one considers memory from the standpoint of reductionism and molecular or episodic memory. Also, the issue of memory erasure should be at least briefly discussed or at least mentioned).

A1: Creating memories requires an increase of h_{eff} and keeping it - h_{eff} tends to decrease by emission of energy. This is why all life requires metabolic energy. Also memory mental images require metabolic energy to survive. They can get it from environment as usual or if not, they acan die and reincarnate with opposite arrow of time and later do this again in the original time direction. Very elegant!

Memory erasure tends to take place spontaneously in ZEO. Mental images die if they do not get metabolic energy feed. In BSFR a large fraction of mental images sub-CD associated with active half of CD disappear since the size of CD decreases in BSFR: this means that new self has childhood and gets rid of the often negative Karma carried by mental images of the later life which is often painful and filled with unpleasant memories.

This also means erasure of unpleasant mental images and liberating also metabolic energy usable by the re-incarnate.

Q2: So, I understand that you are not happy with the behavioristic point of view in this regard. It is OK, however, you have to justify and explain this with an alternative approach. One can represent this as a question. What is the relationship between the behavioristic and TGD views about memories?

A2: Behavioristic picture describes behaviors and learning of them, not episodic memories.

In TGD alll memories as re-experiences (also in symbolicform) correspond to earlier mental images created by say sensory input and continuing to shift towarsgeometric future inside increasing CD and experiencing re-incarnations. If the memory mental images has the same arrow of timeas self, self experiences it as memory mental image.

In TGD the generation of *symbolic* memories as modulations of Josephson radiation frequencies by nerve pulses would correspond to their generation at MB by EEG and its possibly existing fractally scaled up variants as mental images consisting of resonance peaks when the modulated frequency equals to cyclotron frequency of flux tube for some charged particle.

The time scale of the memory is proportional to h_{eff}. Long term memories correspond to rather large values of h_{eff} and to very large layers of MB. The time span of long term memories directly measures the universal IQ as h_{eff} and time and spatial scales of quantum coherence. No memories without dark matter.

In ZEO episodic memory recall would naturally correspond to dark photon signals propagating along closed flux loops back to the brain waking up memory sensory metal images - I almost said "in the brain of the geometric past" but actually it is the brain of geometric future ,where the sensory mental images shift during sequences of SSFRs as CD increases and its upper part shift to the direction of future. When one sends a signal waking up the memory mental images, the latest memory mental images wake up first as the mentione article claims.

Q3: LTP or long-term potentiation means that if an action and or event etc. is repeated, systemic brain and/or neural network and/or a single neuron learn it, and afterwards, cost lesser energy and consume less time to be remembered and/or summoned or practiced. How can one undertand LTP?

A3: Nerve pulse patterns create temporary flux tube networks with flux tubes assignable to axons. Dark photons as carriers of the signals propagate along these. Nerve pulse generation costs metabolic energy. LPT means that the more often the network is created, the easier it is to create it again. This is learning of a habit, not episodic memory.

How to understand LPT in ZEO? Does this living network learn to get the energy needed by nerve pulse patterns by making partial transitions to opposite arrow of time - also nerve pulse is such - making possible extracting it from the environment rather than passively waiting to get it. ZEO would allow the network to become self-sustaining. A habit would develop.

Q4: What about the durations of wake and sleep (ordinary arrow of time and reverse arrow of time): are they equal or not?

A4: The durations of wake and sleep depend on "individual" and depend on the metabolic use: if I use a lot of metabolic energy, I get tired in shorter time and must sleep.

Time reflection is an approximate geometric symmetry of TGD and slightly violated. If the thermo-dynamical reversal of the arrow of time, call it T_{th}, corresponds to T, one can guess that the periods of wake-up and sleep are approximately equal as it seems to be the case in our case. One must be however careful here. There is a rather dramatic violation of CP and therefore T since matter dominates over antimatter in the Universe.

Does one really have $T_{th} = T$? The dark variant of genetic code [Pitkänen 2018c] is represented by dark proton sequences with 3-protons defining a codon. $T_{th} = T$ would replace protons with antiprotons. This cannot be the case. The assumption is indeed that the change of arrow of time changes roles of the boundaries of CD and those of fermionic creation and annihilation operators and $T_{th} = T$ is not true.

Q5: What the addition of MB means from the point of view of metabolism? What about the metabolism during sleep and wake-up?

A5: The presence of MB means additional sink of metabolic energy. "Getting tired" means that metabolic energy resources deplete. Whose? BB or MB or both?

1. TGD predicts that generalized Josephson radiation from neuronal membranes in EEG range communicates sensory input to the MB [Pitkänen 2002, Pitkänen 2010b]. This happens during wake-up state but not during sleep.

   The flux tubes associated with the Josephson junctions accompanying the lipid membrane-membrane proteins, ion channels and pumps act as sending antennas for dark photons during daytime: what is sent is both sensory information and energy to appropriate parts of MB. The frequency of the generalized Josephson radiation would sum formed from the difference of cyclotron frequencies and ordinary Josephson frequency $f = ZeV/h_{eff}$, where V is membrane potential and giving rise to frequency modulation coding nerve pulse activity representing sensory input. The dark photons at MB would resonantly excite the cyclotron states at flux tubes of the large layers of MB, which would eventually decay and emit dark photon radiation.

   Control actions of MB could occur via the dark variant [Pitkänen 2018c] of genome realized as sequences of dark proton triplets representing codons and activating the gene expression. Motor actions are assumed to correspond to BSFRs changing the arrow of time for the flux tubes involved. This means that the control signals could actually extract energy from BB. No energy storage at MB would be needed.

   For the simplest option the only new energy storages would be in the length scales of BB and assignable to the cell membrane and genome and identifiable as cyclotron Bose-Einstein condensates analogous to a population inverted laser. For the cell membrane energy storages would be associated with the flux tube portions at the

two sides of the cell membrane. For the genome they could be magnetic flux tubes of the dark genome with codons realized as dark proton triplets and accompanying DNA.

During the wake-up both these energy storages would be depleted by sensory activities and during sleep they would be recharged.

2. The EEG bands above 10 Hz assigned with wake-up state are absent during sleep so that in these bands the energy transfer to MB would occur only during wake-up. The EEG frequencies present during sleep state would correspond to some kind of sensory input to some parts of MB and corresponding motor response. During sleep MB would be awake in longer scales than during wake-up periods.

The challenge of BB is to build these population inverted lasers during sleep - magnetic flux tubes containing charged particles in excited cyclotron states. Dark photon radiation must do this. Where could it come from? Certainly from the molecules responsible for metabolic energy storage but how?

1. Dark photons transform to bio-photons and induce molecular transitions: this makes possible for MB to control the biochemistry.

2. The chemically stored metabolic energy should be transformed to the energy of Bose-Einstein condensates: the energy of these molecules stored to their bonds would be liberated as they return to less energetic states as photons transformed to dark photos.

3. How could this happen? Here ordinary metabolic mechanism would be at work with produced photons transforming to dark photons unless they are dark enough already (increase of h_{eff} might be required). I have proposed that one has $h_{eff} = nh_0 > h$ for the valence bonds and h_{eff} increases towards the right end of the rows of the Periodic Table containing atoms appearing in metabolite molecules [Pitkänen 2017b]. Molecular transitions during molecular catabolism liberating energy would generate photons and they could be transformed to dark photons with some rate and excite B-E condensates accompanying the Josephson junctions.

   By the fractality of the TGD Universe, a similar mechanism is expected to be a work for ordinary cells but in a scaled wavelength range since the value of h_{eff} is expected to be smaller by the lower evolutionary level: the analog of EEG would be at scaled-up frequency range.

The experimental situation is not yet settled.

1. The mainstream opinion seems to be that the metabolism during sleep is considerably lower than during wake-up. On the other hand, the reduction of energy

metabolism during sleep is reported to be surprisingly small [Nedergaard and DiNuzzo 2017]. This would conform with the proposed view about the population inverted cyclotron B-E condensates as an additional energy storage needed by MB.

2. The summary of the introduction [Nedergaard and DiNuzzo 2017] suggests that during NREM sleep the oxidation of glucose is to a some extent replaced by the oxidation of fatty acids and ketone bodies. This would allow roughly similar metabolic rates during sleep and wake-up. The natural guess is that the metabolic energy from these processes is used to excite cyclotron B-E condensates.

   According to [Nedergaard and DiNuzzo 2017] the catabolism of glucose and glycogen via aerobic pathway is a hallmark of wakefulness, whereas the transition to sleep is marked by decreased brain lactate levels due to decreased production as well as increased glymphatic clearance. The rise in the oxygen-glucose index during sleep would not be due to a reduced aerobic glycolysis, i.e. more lactate oxidation, but rather to a shift towards utilization of fatty acids and ketone bodies as metabolites.

   According to the same reference, the FFA passing from circulation to the brain supports ATP production via mitochondrial β-oxidation (~ 60 per cent). Astrocytes are the primary cell type carrying out fatty acid oxidation and ketogenesis in the brain, whereas the concurrent ketosis probably occurs in neurons. The increased plasma levels of FFAs during sleep probably support the metabolic shift to lipid metabolism compared with normal wake-up state.

   Why this shift? The oxidation of glucose and glycogen are fast processes needed by neural activities occurring in a millisecond time scale and would be naturally used during wake-up periods. Oxidation of fatty acids and ketone bodies are slower processes and could be used to replenish the metabolic energy reservoirs utilized during wake-up to the communications of the sensory data to and control responses by MB. During sleep the time scale for the sensory communications to and control responses by MB at slow EEG waves is a considerable fraction of second and the same energy source could be used.

3. In [Nedergaard and DiNuzzo 2017] glucose and lactate levels are reported to be somewhat similar during REM sleep and waking. The levels are the same for some regions of the brain. The partial wake-up of the MB force wakeup of the brain inducing ordinary metabolism in these regions.

   Note that there is empirical evidence that the brain effectively obeys hyperbolic geometry [Cacciola et al 2017]. The functionally similar neurons in the brain are close to each other in a statistically determined hyperbolic geometry. In the TGD framework the effective hyperbolic geometry could be naturally assigned as a real geometry to the MB of the brain [Pitkänen 2020c]. The neurons which are functionally similar but possibly far away from each other would send their information

along flux tubes to the same part of MB and be near to each other in the hyperbolic geometry. The synchronously firing neurons scattered around the brain and using glucose oxidation could correspond to a region assignable to a mental image corresponding to a connected region of MB.

Q6: Can one formulate these questions within the frame of brain waves (EEG) during wake and sleep? I mean to mention REM and propose some explanations or some answers or some hypotheses do we expect that precognition entails energy cost? Or not?

A6: Ordinary memory recalls require metabolic energy to wake-up memory mental images. Metabolic energy for memory recall by time reversed self looks like a liberation of energy in the standard time direction.

But these memories should be communicated to the self with opposite arrow of time! How? The memory mental images of self with opposite of arrow time can also die and re-incarnate with our arrow of time giving rise to dreams: this would require metabolic energy from our view point. When self forgets, the self with the opposite arrow of time remembers! Dreams and precognition would thus require metabolic energy.

The electromagnetic signals generated by the earthquakes could explain the ability of the native people to predict them several hours before their occurrence. There are also indications that the perception of different electromagnetic signals impending to an earthquake do not cost any ATP in animals: rather there is possibility that extremely low frequency oscillations (1070 Hz) may even enhance ATP synthesis during the earthquake in mammals [Friedemann and Stolc 2013].

The time reversed signal from the geometric future would generate a sensory mental image - sub-self - of the time reversed self. With respect to the arrow of time of the observer this process would liberate energy as the observations indicate. To become an observer's mental image, this sub-self must experience a BSFR. From the observer's point of view this requires metabolic energy. These two contributions to the energy costs are of opposite sign and could also sum up to negative.

Q7: If not, can we consider that the reverse arrow of time is accompanied with negentropy or negative entropy? Why? i.e. if all reverse arrow of time memories or precognitions of the future should correspond with negentropy?

A7: Generalized form of the second law applies to subjective time and states that the entropy increases with respect to the subjective time always. It increases also in the reverse arrow of time but to us in wake-up state it looks like decrease: as if negentropy were generated. For us the system indeed seems to develop ordered structures, to self-organize - rather than losing them as ordinary second law would dictate. Self-organization can be forced by feeding energy to the system or system can have subsystems with non-standard arrow of time extracting energy from the external world by dissipating. This could be a self-sustaining order. It might relate to self-organized criticality which is a concept not well-understood. Systems are able to stay around critical state, which conflicts intuitive picture. TGD Universe is actually quantum critical.

Q8: What about dreams that already happened in our life and we already have experienced them? For example, consider that Person A has divorced his life two years ago at 2018. On 2020, He may have dreamt that he has divorced his wife. Does such a situation entail an energy cost? The energy is not important per se here, but the physical meaning of such a question is of worth for future implications.

A8: If dreams are wake-up of some regions of the sleeping brain creating mental images then they require metabolic energy.

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