Sensory Perception and Motor Action as Time Reversals of Each Other: a Royal Road to the Understanding of Other Minds?

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Abstract

The notion of mirror neuron is extremely attractive because it could allow the understanding of the observed goal directed behaviors of living systems by inducing corresponding imagined or even real actions. The sensory input about behavior would automatically induce the neural activity representing intention about the behavior or imagined behavior. Mirror neuron hypothesis was derived originally for monkeys but has been considerably generalized. For instance, in the case of humans mirro neurons could allow an almost automatic understanding of intentions and emotions of other people.

In TGD framework the objections against mirror neuron hypothesis motivate its replacement with what I call time mirror hypothesis inspired by zero energy ontology, and stating that motor action and sensory perception are in a well-defined sense time reversals of each other. This hypothesis could explain the time anomalies assignable to mirror neurons if they are indeed involved (reactions tend assigned to mirror neurons tend to be "too fast") and also Libet's findings. This inspires the notion of quantum monadology: parts of brain would be continually time mirroring each other. Also magnetic body would be involved. The time mirror relationship could correspond to directed attention having as space-time correlates magnetic flux tubes carrying dark photon signals in both time directions. Time mirror hypothesis is applied to the entrainment of the speech motor regions with auditory areas at the opposite side of brain occurring at resonance frequency 4.5 Hz as discovered by Poeppel and Assaneo.

This vision allows to build a model of sensory memories with motivation coming from the findings challenging the standard view about them. This model in turn inspires a very general model of motor action applying also to basic biochemical processes such as transcription, replication, and translation as being induced by topological quantum computer programs running in non-standard time direction.

1 Introduction

This article was motivated by article in Quanta Magazine (see `http://tinyurl.com/y8a4puca`) telling about the work of David Poeppel and his student Florencia Assaneo.

1.1 Poeppel's criticism of neuro-computationalism

The article inspired the reading of the article "*Neuroscience Needs Behavior: Correcting a Reductionist Bias*" of Poeppel *et al* [J4] (see `http://tinyurl.com/ybeeetr6`) criticizing the computational theory of behavior assuming that behavior reduces to an algorithm analogous to computer program, the software, implemented by neural circuit serving as a hardware.

Poeppel mentions as an example of Caenorhabditis elegans, the roundworm that is one of the most studied lab animals. This animal has only 302 neurons and its neural circuitry is known very precisely as also its full genome. Despite this there is no understanding about what the algorithm encoding the behavior is and how the neural circuitry implements it. Something is missing.

More generally,o ne cannot deduce the behavior of even simple animals from the neural circuitry regarded as computer. Several programs can give rise to the same behavior or same circuitry to several behaviors. The deduction of hypothetical algorithm from behavior is impossible. Poeppel mentions also an experiment in which one tried to deduce from the behavior of the computer game characters the algorithm behind the game for three games. The attempt failed. This finding can be also seen as a failure of behaviorism not anymore a leading dogma in neuroscience anymore since even simple creatures like Caenorhabditis elegans refuse to believe like doorbells.

From the philosophical point of view the failure of reducing behavior to a deterministic algorithm is obvious to me. There is a thing called free will and round worm is not a deterministic computer. One could model its basic behavioral patters using computer programs as analogs but the choice, which program is run involves free will, and one must construct theory of consciousness allowing free will as something consistent with physics. This requires going beyond the recent view about physics.

Poeppel mentions as an example the determination of the direction of a sound source. Depending on the direction sound signal arrived to ears at different times. This can be used as data allowing to deduce the direction of the sound source. There are however several other algorithms for deducing the direction of the sound source.

There is also philosophical criticism. One assumes that there is a small homunculus inside brain able to write computer programs and implement them. This bit virtuoso has found from some text book of physics a formula allowing to determine the direction of the sound source from the time lag between ears and then has written a computer code and implemented it. But how this tiny computer programmer can achieve this?: obviously it must have a tiny computer programmer inside. One ends on with infinite hierarchy of computer programmers inside computer programmers - infinite regress.

How to get rid of this hierarchy of homunculi? Could quantum physics alone with measurement theory extended to a theory of consciousness by making observer a part of physical system be enough to define and understand behaviors. No model for the physical world but just the physical world itself. This requires however new physics in which notions like behavior, intentionality, goal directedness, and memory have a well-defined meaning. All this notions refer to time or time evolution somehow. In standard physics quantum states are however time=constant snapshots so that going beyond standard quantum physics seems to be unavoidable.

Poeppel also talks about a hegemony of methods reducing neuroscience to the study of neurons and forgetting behavior and studying only neural circuits. Poeppel argues that one should start from behaviors, study them in detail and only after that start to study algorithms and neural circuits as possible way - not necessary correct way - to realize behaviors. One should also consider neuron groups besides neurons. The recent trend is however just the opposite: there is even an attempt to reduce behavior to the molecular biology in accordance with nothing-but-chemistry paradigm.

The coherent behavior of neuron groups manifesting itself as synchronous firing of neurons would be the natural starting point. Here one encounters EEG. EEG correlates both with the state of brain and contents of consciousness. Why brain should use large amounts of metabolic energy to communicate information to outer space? Just for fun? Biology does not waste metabolic energy. What is the purpose of this action bringing in mind communication? Who is the receiver? This question has led to a considerable progress in TGD framework [K4, K11] by applying the new physics predicted by TGD [L15].

A further important inspiration for this article came from learning of the basic facts about the notion of mirror neuron (see `http://tinyurl.com/d6svmf7`) briefly discussed in the first article of Poeppel *et al* [J4]. The notion of mirror neuron is extremely attractive because it could allow automatic understanding of the observed goal directed behaviors of living systems. Sensory input about behavior would generate automatically the imagined or even real motor action in some cases and there would be no need for the attempt to understand why sensory input about behavior can be associated to a neural activity representing intention about behavior or imagined behavior.

Mirror neuron hypothesis was deduced by studying macaque monkeys and generalized to higher behaviors of humans without testing it at neuron level since this was not possible ethically. The essential assumption is that understanding reduces to single neuron responses. Synchoronous neural firing is involved and therefore also EEG waves, whose real function is not known, are involved so that this kind of reductionism need not be realistic. One can also ask how neurons learn to be mirror neurons: could mirror neuron activity be understood in terms of sensory-motor associations.

The list of the proposed applications to humans is impressive: understanding intentions, imagination, learning facilitation, learning by imitation, automatic imitation and intentional motor mimicry, understanding and learning of language, empathy, autism, theory of mind, human self awareness. Also not so obvious applications such as understanding of gender difference, sleep paralysis - disinhibition of mirror neuron system, hallucinations, and empathy characterizing schizophrenia. One can however argue that mirror neuron hypothesis is not realistic in its strong form stating that observed behavior (bodily motor action) active mirror neurons, which induce the motor action.

The proposed applications of mirror neuron hypothesis in its strong form lead to many inconsistencies. Poeppel mentions [J4] what he calls merological fallacy: psychological properties assignable to entire organism are assigned to single neuron. Behavior is used to deduce hypothesis that mirror neurons understand - a more realistic approach would rely in neuron groups and this again brings in EEG and the questions raised by its unknown function. There are critical articles about mirror neurons describing in detail various failures [J9, J10, J6] (see `http://tinyurl.com/y7jqljwv`, `http://tinyurl.com/y8pelhhl`, and `http://tinyurl.com/y7vhyfe6`). The most intriguing anomalies from TGD point of views relate to time anomalies: mirror neurons would act too fast, considerably

faster than simple estimates based on the rate of nerve pulse conductions and neural information processing allow.

1.2 Brain wave synchrony between brain regions related to speech understanding and speech production

The popular article (see `http://tinyurl.com/y8a4puca`) that inspired this article mentioned also an article [J5] (see `http://tinyurl.com/y79r62v9`) by David Poeppel and his student Florencia Assaneo. The frequency f for syllables of understandable speech varies between 2 and 7 Hz and the average frequency of the syllables in various languages is about 4.5 Hz. Auditory region related to the understanding of speech - Wernicke's area - entrains with the frequency for the rate for syllables in the range 2-7 Hz.

The discovery was that speech motor region - Broca's area- at opposite brain hemisphere - entrains with the auditory region in the range 4-5 Hz and resonance occurs around 4.5 Hz. Therefore the synchronous firing and associated brain waves could play an essential role in the understanding of speech. The interpretation could be that the speech input at these frequencies generates internal speech as imagined motor action not propagating to the level of speech organs (usually).

1.3 Time mirror relation and mirror neuron hypothesis

TGD based model for behavior and also mirror neurons relies on TGD inspired theory of consciousness [L10] in which zero energy ontology (ZEO) plays a crucial role. ZEO predicts that the arrow of time can vary and indeed does so in living matter. A natural conjecture is that sensory perception and motor action are time reversals of each other so that motor action would be sensory perception in reverse time direction. Sub-selves of self - mental images - would form an analog of monad network introduced by Leibniz long time ago. They would however reflect each other time direction rather than spatial directions: ...-sensory-motor-sensory...

Time mirror hypothesis explains surprisingly many time-related anomalies in living matter and neuroscience such as the classical discovery of Libet [J2] that neural activity precedes conscious decision by a fraction of second: physicalistic explanation would be forced to give up free will. The study of mirror neurons has revealed further anomalies of this kind: in particular, mirror neurons react much faster than the estimates based on the conduction velocities of nerve pulses and the rates of information processing in brain would suggest. If motor action is sensory perception in reversed time direction, one could get rid of these anomalies. Quite generally, sensory perception of B by A and its time reversal as motor action would be fundamental building brick in conscious information processing and would allow to use memory storages in geometric past to generate planned responses in much shorter time than velocities of nerve pulse conduction would suggest.

Besides the sensory-motor duality as time reversal, the TGD based view about space-time and classical fields predicts that any system has field identity - field body or magnetic body (MB) and that MB can be seen as an intentional agent using biological body as a sensory receptor and motor instrument. A further piece in TGD story is the identification of dark matter as a hierarchy of phases of ordinary matter labelled by the value of $h_{eff} = n \times h_0$ of effective Planck constant and residing at MB. In this framework the observed entrainment of left and right language regions around 4.5 Hz can be seen as additional support for the idea that EEG is involved with communication from brain to MB possessing a hierarchical onion-like structure corresponding to analogs of EEG at in various frequency ranges.

This vision allows to build a model of sensory memories with motivation coming from the findings [J3] challenging the standard view about them. This model in turn inspires a very general model of motor action applying also to basic biochemical processes such as transcription, replication, and translation as being induced by topological quantum computer programs running in non-standard time direction.

2 TGD based model for sensory-motor consciousness

TGD based model for sensory-motor consciousness relies on the hypothesis that sensory perception and motor action are time reversals of each other. Second assumption is that sensory percept and therefore also motor action is constructed by an iterative process involving forth-and-back communications by dark photons between sensory areas and sensory organs at which sensory qualia are assigned in TGD framework (this is possible assuming ZEO based view about time). The outcome of this iteration is standardized mental image as near as possible to the sensory input picking up only the features relevant for survival.

This process could correspond to single sub-self representing mental image and communications in single direction of geometric time. A more general view is that this process corresponds to a sequence of this kind of iterations as sequence of re-incarnations of mental images so that communications in both directions of time would be involved. The prediction is that sensory consciousness is not a continuous stream but contains black spots.

2.1 Basic ideas of TGD related to consciousness and biology

It is good to start by listing the basic assumptions of TGD inspired quantum theory of consciousness and of biology.

MB is central for TGD inspired biology.

1. A first key notion appearing at the level of TGD inspired quantum biology is due to the differences between Maxwellian and TGD based view about classical em fields. In Maxwellian world the em fields of separate systems superpose and the information is lost much like in the formation of sum 7= 3+4: one does not know whether '7' is the outcome of 7+0, 6+1,5+2, or 4+3. Now one does not know what the fields in the superposition are. In TGD framework many-sheeted spacetime stores the information since the fields of given system are at their own space-time sheets defining field identity, field body or MB.

   MB has hierarchical onion-like structure corresponding to different lengths scales. The communications from biological body to EEG and vice versa are possible by the generalization of EEG. Josephson radiation assignable to cell membrane mediates information about sensory input and MB controls BB by using cyclotron radiation as a tool.

   One can say that MB serves as an intentional agent using biological body as a sensory receptor and motor instrument. Biochemistry would be controlled by MB and represent a kind of shadow dynamics. The MB of DNA is conjectured to realize genetic code in terms of dark proton sequences with entangled state of 3 protons defining genetic codon. Similar picture applies also to other basic biomolecules. This encourages the hypothesis that inheritance is basically realized at the level of MB and genes code for 4-D dynamical patterns - biological functions - rather than only for 3-D structures.

2. MB can be seen as 4-D entity rather than 3-D object. The biological interpretation of 4-D MB would be as the classical correlate for behavior. In WCW picture the second end of MB at the active boundary of CD cannot be fixed like the end at the passive boundary to single state. For the cognitive representations with finite measurement resolution to be discussed below this could be the case so that one could speak of unique classical space-time in fixed measurement resolution in accordance with everyday thinking. In fermionic degrees of freedom one cannot fix the state at active boundary.

   MB is preferred extremal of the action and satisfies extremely powerful additional conditions so that it represents kind of archetypal field pattern. 4-D MB is also analogous to a computer program and the superposition of time evolutions of MB could be regarded as quantal computer program running. State function reductions as acts of free will put a new program running.

Adelic physics is second central part of TGD.

1. Number theoretic vision about physics - adelic physics [L8, L9] leads to the hypothesis about hierarchy of effective Planck constants $h_{eff} = n \times h_0$ defining a hierarchy of phases of ordinary

matter identified as dark matter. n corresponds to the dimension of extension of rationals and for Galois extensions to that of Galois group. The larger the value of n, the larger the maximal value of p-adic entanglement negentropy so that n serves as a kind of IQ. The energies of quantum states as function of n increase and the increase of n requires a feed of metabolic energy.

2. The preferred p-adic primes p are tentatively identified as ramified primes for which the ordinary primes do not decompose to a maximal number of primes of extension but there are less than the maximum number of them and some primes occur several times. There is a direct analogy with the decomposition of polynomials to a product of monomials. At criticality some roots co-incide and power of monomial appears. The natural interpretation would be in terms of quantum criticality.

3. p-Adic length scale hypothesis [K10] emerged via p-adic mass calculations already before I had not realized that p-adic physics is an excellent candidate for the physics of imagination, intention, and cognition and is in central role in concrete applications. For instance, the length scale range between 10 nm and 2.5 μm especially relevant for biology contains four Gaussian Mersenne primes - this is a number theoretical miracle [K8].

4. In adelic physics imagination would correspond to the failure of strict determinism of p-adic differential equations due to the existence of p-adic pseudo constants - functions depending on finite number of pinary digits but having vanishing derivative. The challenge is to find concrete examples in which this p-adic vision about cognition, imagination, and intention is be realized. The challenge is not easy since p-adic number fields represent mathematics completely new for even physicists.

TGD inspired theory of consciousness [L10] relies on zero energy ontology (ZEO).

1. ZEO based theory of quantum measurement allowing to solve the basic paradox of the standard quantum measurement theory make observer part of the physical. The nondeterministic causality of free will and deterministic causality of unitary time evolution and of classical field equations are not in conflict anymore. The basic outcome is the notion of self as a conscious entity.

   Causal diamond (CD) and zero energy state are the key notions of ZEO. Zero energy state is a superposition of pairs of ordinary quantum states at opposite boundaries of CD with members having opposite total quantum numbers to guarantee classical conservation laws for the time evolutions connecting the members also classically. These pairs are analogous to events with members of zero energy state defining analogs of initial and final state of both classical and quantal time evolution.

2. Evolution of self can be seen as a sequence of unitary evolutions leaving the passive boundary of CD and members of states at it unaffected but inducing dispersion of the active boundary in the moduli space of CDs. This is followed by "small" state function reduction defining an analog of weak measurement (see `http://tinyurl.com/zt36hpb`) inducing localization of the active boundary of CD in the moduli space, in particular meaning measurement of clock time identified as temporal distance between the tips of CD. As a consequence, the size of CD increases at least in statistical sense and this is experienced as flow of time.

   The process eventually stops since one expects that all observables are eventually measured and further time evolution would require extension of rationals involved if one wants that the eigenstates of density matrix are still in the extension. The proposal is that the extension cannot increase in "small" state function reduction. Next step is "big" state function reduction as analog of ordinary state function reduction in which the roles of boundaries of CD are changed. Self dies and reincarnates in opposite time direction and CD starts to increase in opposite time direction.

3. Since deterministic time evolution of state replaces time= constant snapshot as a basic notion, this leads to a new view about geometric time and its relation to experienced time: one can speak about 4-D brain, about signalling in both time directions, a new view about memory emerges, and various time anomalies such as that found by Libet [J2] find an explanation.

4. Motor action as time reversal sensory perception is a conjecture made for years ago. The challenge is to find support for the hypothesis. In this article this hypothesis is studied in more detail and the generalization of mirror neuron hypothesis to time mirror hypothesis is proposed. This generalization would apply to any conscious entity and one could see all conscious entities perceiving each other and interacting as kind of Leibniz monads time mirroring each other.

2.2 Challenging ZEO and CDs

In order to proceed it is best to not forget to invent objections against the the new assumptions. The notion of ZEO and CD are the certainly such notions.

There are critical questions related to the definition of the hierarchy of CDs.

1. What determines CD? Somehow the space-time dynamics should do it without any ad hoc assumptions. There are indeed strong indications from $M^8 - H$ correspondence, that CDs emerge naturally from the properties of octonionic polynomials [L6].

   For instance, 8-D Poincare transformation generate different octonion structures and time axis as real axis for octonions must contain the tips of CD. The preferred octonionic coordinates are highly unique and allow only the rotations leaving time axis defining the rest system invariant. Poincare symmetries are real symmetries but change the octonion structure. If the definition of octonion structure involves also the preferred associative subspace as $M^4 \subset M^8$ and the choice $M^2 \subset M^4$ as preferred commutative sub-space, the coordinates are highly unique as required by the number theoretic vision. This uniques corresponds to uniqueness at the level of H.

2. Do space-time surfaces continue beyond CD or do they have naturally ends at boundaries of CD? For instance, could it happen that all the roots for the octonionic polynomials become complex outside CD so that one cannot have real roots. If one requires that space-time surface corresponds to real root rather than projection to a real sub-space of M^8 this cold force CDs. Why the ends would be M^4 light-cones (with points replaced with CP_2? Twistor Grassmann approach [K5, K14] suggests that CDs can contain sub-CDs connected by the analogs of lines of twistor diagrams and represented as 4-surfaces representing mass shall particles in complex sense and having minimal surfaces as space-time correlates.

3. Can CDs intersect and overlap and how to describe this mathematically at space-time level? What would be the physical interpretation for the overlap?

One can also invent criticism related to conscious experience.

1. CDs would represent kind of spot-light of consciousness defining 4-D perceptive field of sub-self. The size of CD increases reduction by reduction at least in statistical sense. Sub-selves of self would correspond to mental images and have sub-CDs as embedding space correlates.

   The intuitive idea is that mental images can appear and disappear. Does this mean that sub-CDs can also appear and disappear in some sense? Is this natural mathematically?

   Conservation laws force the total quantum numbers at its opposite boundaries to be opposite. The analogy of zero energy state in QFT would be vacuum fluctuations. The CD and corresponding zero energy state would obey the usual evolution giving rise to self. If CD of finite size has vacuum quantum numbers at its both boundaries, its creation from vacuum is allowed by conservation laws. Is this kind of zero energy state for any CD equivalent with having no CD at all? If so then the disappearance of mental images is possible if the mental image contains in its wave function also vacuum-vacuum part carrying no information.

2. It has been assumed that CDs increase monotonously in size during the sequence of "small" state function reductions giving rise to self as a generalized Zeno effect. The assumption about monotonic increase of size is however un-necessarily strong. The reason is that in the moduli space of CDs (determined by the action of Poincare group and size scale of CD) the number of CDs larger than given CD is infinitely larger than those with smaller size so that in statistical sense CD is bound to increase.

3. What about sub-selves of given self? Is self conscious also about its sub-selves with an opposite arrow of time? If one looks at lamp and closes eyes, one finds that the after image appears and disappears periodically. If this corresponds to a periodic re-incarnation of sub-self, the sub-selves with opposite time orientation would not be experienced as mental images by self. The interpretation of sensory percept in opposite time direction as a motor action would make the absence of after image natural.

4. The idea that big state function reductions take place when the density matrix has eigenvalues not belonging to the extension of rationals defining the entanglement coefficients is very attractive number theoretically but can be claimed to be somewhat ad hoc.

2.3 ZEO based model for sensory-motor consciousness

Let us summarize the ZEO based view about sensory-motor consciousness.

1. Quantum jumps between superpositions of temporal patterns define selves and therefore also mental images in ZEO. Consciousness is in the quantum jumps - between initial and final worlds - rather than in the world itself so that consciousness is not a property and one should not use "-ness" of physicalist.

   That visual consciousness fades if the pupil is not in saccadic motion relative to the visual field conforms with the prediction that consciousness in the quantum jump replacing the quantum world with a new one.

2. Motor action is identified as time reversal of sensory perception. The interpretation in standard direction of time is as a motor response. During this period there would be not sensory consciousness. The phenomenon of after images supports the vision about sequence of re-incarnations of mental images as sub-selves. Even the prediction of re-incarnation, which certainly tests the patience of physicalist, finds direct support. The temporary absence of after image correspond to an after image living in opposite direction of time and having interpretation as motor action. The mental images with time direction opposite to that of self would not be consciously experienced.

3. In the model proposed earlier [L5] sensory mental images are produced by iteration in which signals travel forth and back between sensory organ and brain (and even MB and sensory organ) and the virtual sensory input adds to the real one to generate standardized mental images containing only the features relevant for survival. This would be essentially pattern recognition, finding the standard mental images nearest to the sensory input by using virtual sensory input.

   The signalling is by dark photons - nerve pulses would be quite too slow for this purpose and they would only generating communication pathways - kind of wave guides - by building transmitter bridges connecting pre- and post-synaptic neurons. The flux tubes of MB would accompany axons and dark photons would propagate along them.

4. One can ask whether the forth-and-back communication is in a fixed direction of time or whether the time direction varies so that one would have a sequence of re-incarnations for mental images: ...-sensory-motor-sensory-...

   It must be emphasized that each step between two time reflections involves a sequence of unitary evolutions followed by weak measurements, and that this period could involve forth and back communications between sensory organ and say brain with single direction of time. Therefore both mechanisms could be involved. One can also argue that the virtual sensory input should contain the component in the standard time direction. If it were in the opposite direction of time only, it is not clear whether it could superpose with the ordinary sensory input.

   The sensory input in opposite time direction is free from the limitations posed by the finite conduction velocity of nerve pulses and light-velocity. In principle, time travel to the layers of MB in distant past providing information about memories could contribute to the eventual motor response. Also now time would grow in the sense that the size of CD grows in statistical sense at least.

One could also speak of pattern recognition in 4-D sense at classical level. For cognitive representations in terms of common points of real and p-adic space-time surfaces (belonging to an extension of rationals) there could be a complete localization in the "world of classical worlds" (WCW) to a discretized space-time surface. Actually this would be only localization modulo finite measurement resolution.

5. This picture would apply as such to motor action. Also motor action would be generated by a similar sequence using virtual sensory input in opposite time direction to reach standard motor output. Also sensory and motor imagination can be understood in this framework as also hallucinations and psychedelic experiences [L2].

6. The basic prediction is gaps in sensory (say visual) consciousness due to the motor actions inducing a motion of sensory organ or part of it, say pupil. By looking at mirror anyone can indeed verify that eye cannot see the motion of pupil. A general qualitative implication would be that the performance on motor action is optimal when sensory input is minimal and vice versa. It is known that sensory consciousness is not continuous but contains black spots.

   It is known that during attention shift visual consciousness is lost (see `http://tinyurl.com/ych6atb6`), and since saccadic motion means shifting of attention, one can argue that visual awareness is lost during the motion of pupil.

   Saccadic motions (see `https://en.wikipedia.org/wiki/Saccade`) induced by an unexpected stimulus normally take about .2 seconds to initiate, and then last from about 20–200 ms (20–30 ms is typical in language reading). The estimate for the duration of the sensory mental image is about .1 seconds as cronon of sensory subjective time. If the unexpected stimulus emerges during visual mental image it does not affect it since attention is not directed towards it yet. Mental image must die and re-incarnate in reversed time direction as motor action inducing saccadic motion. After that reincarnation in the original time direction as visual mental image would occur. This would take about .2 s at least.

   Attention blinking (see `https://www.verywellmind.com/what-is-attentional-blink-2795017` is an analogous phenomenon. The subject person perceives a rapid series of numbers in monitor and is asked to report when she sees numbers 2 and 7 in successions. It turns out that if the numbers follow each other within time interval about .5 seconds, the subject does not notice their appearance. This suggests that the duration of sensory percept is about .5 seconds and longer than the time scale about .1 seconds providing estimate for the lifetime of visual mental image. A hierarchy of time scales is predicted and attention blinking would correspond to a considerably longer time scale in the hierarchy.

Pieces of evidence for this vision emerge from various time anomalies of consciousness.

1. Libet's findings [J2] about neural activity preceding conscious decision are so familiar that there is no need to repeat them. The reaction times of boxers are of order 60 ms and are too fast to be understood in terms of neuroscience. Penrose has also described similar strange findings in the case of tennis players. There are also strange findings in the case of mirror neurons. All these findings can be understood if motor action is sensory perception in reversed time direction.

2. The observed de-synchrony of motor neurons after motor action came as a news to me. Synchrony is identifiable as a correlate of quantum coherence at the level of MB controlling the neurons. It has TGD based interpretation in terms of "big" state function reduction changing the roles of motor neurons and of motor organs. Motor organs become quantum coherent passive boundary of CD and neuronal end of CD becomes active boundary and ceases to be in synchrony.

Motor action as a time reversal of sensory percept inspires fascinating ideas [L2] [**?**, K17, K12, K7] about communications with geometric past since light-velocity ceases to be a limiting factor and one can visit in distant past. TGD based vision about memories indeed is that the geometric memories are in geometric past, in principle where the events first happened. It is of course possible

possible and useful to construct copies of the memories and active memorizing by repeated memory recalls would be one form of learning.

In this picture sensory percept would be followed by a visit to geometric past or even sequences of visits forth and back to rummage memories. Only the time lapse assignable to the increase of the size of CD would pose limits on the time used. This might revolutionize the picture about sensory and motor consciousness.

2.4 p-Adic physics as correlates of imagination, cognition, and intention

The idea that p-adic physics could provide physical correlates of imagination, cognition, and intentionality is very attractive. The challenge is to formulate in more concretely and perhaps even find direct applications in neuroscience.

2.4.1 Imagination, intention, cognitive representations and real world

p-Adic preferred extremals involve p-adic pseudo constants having vanishing derivative by definition and depending on finite number of pinary digits. For p-adic extremals having interpretation as real preferred extremals the pseudo constants become genuine. Imagination is realized when p-adic pseudo constants are possible.

1. This inspires the general idea is that motor action is generated by a repeated trial and error procedure in which p-adic variant of the preferred extremal is replaced by a more realistic one. The real counter part of p-adic preferred extremal would increase in size scale and eventually connect both boundaries of CD and define a realization of intention as action. I have compared this process to building a four-dimensional statue starting from a rough sketch.

2. One has two interpretations for what this could mean at the level of motor system. Motor action as time reversal of sensory action would suggest that the process begins from muscles as time reversed sensory signal providing a rough sketch of the motion and is reflected back if the completion to full real extremal fails and followed by a new trial. The process would be repeated until full realization would be achieved. In standard direction of time motor action would begin from brain as neuroscience pictures it or even MB. This would conform with the fact that we experience the motor action as starting from muscles rather than brain. The intuitive picture that MB controls brain rather than muscles conforms with the idea of motor action as time reversed sensory perception.

   A similar description would apply to sensory perception in standard time direction. The forth-and-back iteration as trial and error process would proceed gradually to higher and higher levels in the hierarchy starting from sensory organ and continuing via primary, secondary and tertiary sensory areas and eventually possibly reaching MB via EEG.

There are several descriptions for this completion process giving rise to a full perception or motor action via trial and error process.

1. Continuum picture is based real and p-adic space-time surfaces. Here the notion of "world of classical worlds" (WCW) is essential [K13]. At this level strong form of holography (SH) allows a formulation of the idea about completion of intention to action. One can assign data to 2-D surface and continue so that it gives 4-D space-time surface by strong form of holography.

   In p-adic case this is easy by the existence of p-adic pseudo constants. In the real case the continuation need not be possible. If p-adic pseudo constants can be chosen to be genuine constants then the realization of imagination and intention is realizable.

2. Second view is based on discrete cognitive representations as intersection of p-adicities and reality [L8, L9]. One assigns to real and p-adic preferred extremals common points having coordinates in the extension of rationals considered. The symmetries of the embedding space allow very restricted class of preferred coordinates so that problems with general coordinate invariance can be overcome. This set of points is discrete and perhaps even finite set.

3. $M^8 - H$ duality provides a third view. One must complexify M^8 so that one has complexified octonions M_c^8. This means the addition of imaginary unit i commuting with octonionic imaginary units. The vanishing of real or imaginary part of octonionic polynomial in quaternionic sense ($o = q_1 + Jq_2$) defines the space-time surface. Octonionic polynomial itself is obtained from a real polynomial by algebraic continuation so that in information theoretic sense space-time is 1-D. The roots of this real polynomial fix the polynomial and therefore also space-time surface uniquely. 1-D line degenerates to a discrete set of points of an extension in information theoretic sense. In p-adic case one can allow p-adic pseudo constants and this gives a model for imagination.

   The roots $x + iy$ of the real polynomial need not however be real. There are two options.

   (a) I have proposed in [L6, L7] that the *projection* from M_c^8 to real M^4 (for which M^1 coordinate is real and E^3 coordinates are imaginary with respect to i!) defines the real space-time surface mappable by $M^8 - H$ duality to CP_2.

   (b) An alternative option, which I have not considered in the original versions of [L6, L7] is that only the roots of the 4 vanishing polynomials as coordinates of M_c^4 belong to M^4 so that m^0 would be real root and m^k, $k = 1, ..., 3$ imaginary with respect to $i \to -i$. M_c^8 coordinates would be invariant ("real") under combined conjugation $i \to -i, I_k \to -I_k$. In the following I will speak about this property as *Minkowskian reality*. This could make sense. Outside CD these conditions would not hold true. This option looks more attractive than the first one. Why these condition can be true just inside CD, should be understood.

4. The first two approaches would be equivalent if $M^8 - H$ duality defines the cognitive representations as roots of polynomials. The use of polynomials or rational functions could be also an approximation. Analytic functions of real variable extended to octonionic functions would define the most general space-time surfaces but the limitations of cognition would force to use polynomial approximation. The degree n of the polynomial determining also $h_{eff} = nh_0$ would determine the quality of the approximation and at the same time the "IQ" of the system.

Consider now the third approach in more detail.

1. One argument against number theoretic vision is that it breaks general coordinate invariance since the choice of cognitive representation depends on the choice of embedding space coordinates. At level of M^8 this objection can be circumvented since the choice is highly unique. 8-D Poincare transformations generate different octonion structures and time axis as real axis for octonions must contain the tips of CD. The preferred octonionic coordinates are highly unique and allow only the rotations leaving time axis defining the rest system invariant. Poincare symmetries are real symmetries but change the octonion structure. Since the definition of octonion structure involves also the preferred associative subspace as $M^4 \subset M^8$ and the choice $M^2 \subset M^4$ as preferred commutative sub-space, the coordinates are highly unique as required by the number theoretic vision. This uniqueness induces uniqueness at the level of H.

2. One can think of starting from one of the 4 vanishing conditions for the components of octonionic polynomial guaranteeing associativity. Assuming real roots and continuing one by one through all 4 conditions to obtain 4-D Minkowskian real regions. The time coordinate of M^4 coordinates is real and others purely imaginary with respect to $i \to -i$. If this region does not connect 3-D surface at the boundaries of real CD, one must make a new trial.

   Cusp catastrophe determined as the zero locus of third order polynomial provides an example. There are regions with single real root, regions with two real roots (complex roots become real and identical) defining V-shaped boundary of cusp and regions with 3 real roots (the interior of the cusp).

3. The restriction of the octonionic polynomial to time axis m^0 identifiable as octonionic real axes is a real polynomial with algebraic coefficients. In this case the root and its conjugate

with respect to i would define the same surface. One could say that the Galois group of the real polynomial characterizes the space-time surface although at points other than those at real axis (time axis) the Galois group can be different.

One could consider the local Galois group of the fourth quaternionic valued polynomial, say the part of quaternionic polynomial corresponding to real unit 1 when other components are required to vanish and give rise to coordinates in $M^8 \subset M_c^8$ - Minkowskian reality. The extension and its Galois group would depend on the point of space-time surface.

An interesting question is how strong conditions Minkowskian reality poses on the extension. Minkowskian reality seems to imply that E^3 roots are purely real so that for an octonionic polynomial obtained as a continuation of a *real* polynomial one expects that both root and complex conjugate should be allow and that Galois group should contain Z_2 reflection $i \to -i$. Space-time surface would be at least 2-sheeted. Also the model for elementary particles forces this conclusion on physical grounds. Real as opposite to imagined would mean Minkowskian reality in mathematical sense. In the case of polynomials this description would make sense in p-adic case by allowing the coefficients of the polynomial be pseudo constants.

4. What data one could use to fix the space-time surface? Can one start directly from the real polynomial and regard its coefficients as WCW coordinates? This would be easy and elegant. Space-time surface could be determined as Minkowskian real roots of the octonionic polynomial. The condition that the space-time surface has ends at boundaries of given CD and the roots are not Minkowskian real outside it would pose conditions on the polynomial. If the coefficients of the polynomial are p-adic pseudo constants, this condition might be easy to satisfy.

The situation depends also on the coordinates used. For linear coordinates such as Minkowski coordinates Minkowskian reality looks natural. One can however consider also angle like coordinates representable only in terms of complex phases p-adically and coming as roots of unity and requiring complex extension: at H-side they are very natural. For instance, for CP_2 all coordinates would be naturally represented in this manner. For future light-cone one would have hyperbolic angle and 2 ordinary angles plus light-cone proper time which would be real and positive coordinate.

This picture conforms with the proposed picture. The point is that the time coordinate m^k can be real in the sense that they are linear combinations of complex roots, say powers for the roots of unity. $E_c^4 \subset M_c^8$ could be complex and contain also complex roots since $M^8 - H$ duality does not depend on whether tangent space is complex or not. Therefore would could have complex extensions.

3 TGD view about mirror neurons

Mirror neurons provide an application for the TGD view about sensory-motor activity replacing mirror neuron hypothesis with time mirror hypothesis.

3.1 Basic facts about mirror neurons

A mirror neuron (see `http://tinyurl.com/d6svmf7`) is a neuron that fires both when an animal acts and when the animal observes the same action performed by another. Mirror neurons were discovered by studying macaques: the inferior frontal gyrus (region F5) and the inferior parietal lobule were found to contain them. Mirror neurons are motor neurons firing when the animals perceives visually motor action and also when animal itself generates a goal directed motor action. 10 per cent of neurons in inferior frontal and inferior parietal cortex of macaques are mirror neurons. The mirrored motor actions could correspond to heritable genetic factors.

Such neurons have been directly observed in some primate species. Birds have been shown to have imitative resonance behaviors and neurological evidence suggests the presence of some form of mirroring system. For ethical reasons the testing of the hypothesis is not possible at neuronal level for humans and other methods such as fMRI must be used. Bain activity consistent with that of mirror neurons has been however found in inferior frontal cortex, premotor cortex, supplementary motor area, the primary somatosensory cortex and the superior parietal lobe.

The function of the mirror system in humans is a subject of much speculation. Some researchers in cognitive neuroscience and cognitive psychology consider that this system provides the physiological mechanism for the perception/action coupling (see the common coding theory). They argue that mirror neurons may be important for understanding the actions of other people, and for learning new skills by imitation. Some researchers speculate that mirror systems may simulate observed actions, and thus contribute to theory of mind skills, while others relate mirror neurons to language abilities. Neuroscientists such as Marco Iacoboni (UCLA) argue that mirror neuron systems in the human brain help us understand the actions and intentions of other people. In a study published in March 2005 Iacoboni and his colleagues reported that mirror neurons could discern whether another person who was picking up a cup of tea planned to drink from it or clear it from the table. In addition, Iacoboni has argued that mirror neurons are the neural basis of the human capacity for emotions such as empathy.

In humans mirror neurons would be involved in action knowledge, imitation and pantomime interpretation (not possessed by adult monkeys), and biological motion perception. Supplementary motor area and medial temporal cortex would be also involved. In the case of language interpretation possibly as internal speech speech motor region - Broca's region proposed to be a homologue of monkeys ventral premotor cortex, and Wernicke's are in opposite brain hemisphere responsible for speech perception are especially interesting.

Many functions for mirror neurons have been suggested and some of the are not consistent with what has been found in monkeys or have not been found in monkeys. The list of the proposed applications to humans is impressive: understanding intentions, imagination, learning facilitation, learning by imitation, automatic imitation and motor mimicry, understanding and learning of language, empathy, autism, theory of mind, human self awareness. There are also not so obvious applications such as understanding of gender difference, sleep paralysis - disinhibition of mirror neuron system, hallucination, and empathy characterizing schizophrenia. Mirror neuron hypothesis is however criticized as being too limited in its basic form stating that the strong form stating that observed behavior (bodily motor action) activates mirror neurons, which induce the motor action.

3.2 Time mirror mechanism as TGD counterpart of mirror neuron hypothesis

Time mirror hypothesis is a natural generalization of mirror neuron hypothesis in TGD framework. The two systems would to correspond to opposite ends of CD and in big state function reduction their roles would change.

3.2.1 When two systems can be in time mirror relationship?

When two systems can be in time mirror relationship?

1. Speech and its understanding are in very special role as also the results of Poeppel and his student [J5] show. In TGD framework the time mirror relationship would be between the brain regions involved with the understanding of speech at and those involved with speech production at the opposite hemisphere.

2. The model for the generation of sensory percept as a forth-and-back communication between sensory organ and brain (or even MB) involving dark photon signals propagating with light velocity in same time direction. Time mirror hypothesis applied to sensory organs and brain suggests a generalization of this picture: sensory organ and the sensory cortex are in time mirror relationship making possible a sequence of reincarnations of the mental image so that signals can proceed in both directions of time. This would conform with the fact that the sensory consciousness has gaps.

3. Could any mutually communicating brain regions be in time mirror relationship? The presence of magnetic flux tubes along which dark photons can propagate is assumed to serve as a correlate for directed attention. Could their presence guarantee also the time mirror relationship. For instance, the neuron groups of primary, secondary and tertiary sensory and motor regions, and premotor regions and primary motor regions attend to each other and therefore be in time mirror relationship. This could be true also for the regions of brain and

parts of MB. This would conform with the hypothesis that MB both perceives and controls biological body and is responsible for the third person aspect of consciousness [K15]. This would conform with Leibnizian monadology.

4. Could even sensory organs and target of attention be in time mirror relationship? The perceiver could to some degree control the target of her attention. It is known that authoritative and charismatic persons such as performing artists can have very strong effect to persons that they attend and are attended by. Could also hypnosis be based on the same mechanism [K6]. The motor reaction of the attended target could come come "too fast", even before becoming becoming target of attention.

   If directed attention induced by flux tube connections is enough for time mirror relationship then mirroring property is not static and depends on the relationship between two subsystems. Learning of mirror property would be generation of directed attention. This would make the model more flexible.

3.2.2 Time mirror hypothesis and the basic aspects of mirror neuron activity

Time mirror hypothesis allows to understand the basic aspects assigned with mirror neuron activity.

1. The percept of motor activity generates imagined or even real motor activity. Internal speech as almost speech is one example. Also real motor activity is generated by the same neuronal activity but for some reason the activity does not proceed to the muscles.

2. Mirror neuron activity is able to distinguish between biological motion and motion of inanimate matter. Time mirror hypothesis reduces the question to that about which systems can be in time mirror relationship. It is obvious that motor neuron activity cannot induce motion of in-animate matter since it is not under motor control so that the problem disappears.

   An interesting question relates to the possible distinction between actual motion and video about actual motion. If the attention involves formation of flux tubes between target and perceiver, there might be differences.

3. Mirror neuron activity seems to require goal directedness of the action meaning that the action is intentional. Time mirror hypothesis allows to understand also this.

3.2.3 Time mirror hypothesis and criticism of mirror neuron hypothesis

In the following I consider the criticism of mirror neuron hypothesis [J9, J10, J6] (see `http://tinyurl.com/y7jqljwv`, `http://tinyurl.com/y8pelhhl`, and `http://tinyurl.com/y7vhyfe6`) from the point of view of TGD.

There are several time anomalies involved.

1. Typically mirror neurons react "too fast" [J10, J6]. Sensory-motor associations are too slow to explain these time anomalies for the same reason so that the question is not about mechanism but about the view about time.

2. Measurements of neuron firing delay seem to be incompatible with standard reaction times [J10, J6]. The articles [J10, J6] mention boxers an an example. The estimate for the reaction time based on the knowledge of the conduction velocity of nerve pulses and neural processing would be about 200 ms. The actual reaction time is around 60 ms. The boxer cannot automatically perform the mirror the motion of the opponent but must be able to decide what to do on basis of the perceived motion. If mirror neurons are involved, there must be a step involving a reaction to the mirrored bodily movement with different movement.

   One could argue that anticipation based on facial expression realized in terms of mirror neurons is in question. But also now the mirror neuron response would be facial expression, real or imagined! Penrose mentions as similar example about tennis players in "Shadows of Mind" [J12]: in this case seeing of the facial expression is not possible.

3. Only the type of action, and not the kinematic force with which models manipulated objects, determines neuron activity. According to [J10, J6] it was also significant that neurons fired *before* the monkey observed the human model starting the second motor act (bringing the object to the mouth or placing it in a cup). Therefore, IPL neurons "*code the same act (grasping) in a different way according to the final goal of the action in which the act is embedded*". They may furnish a neural basis for predicting another individual's subsequent actions and inferring intention. How the mirror neurons knew that the action is goal directed and intended to a particular goal although there was no information about it. Also in this case the same TGD based explanation applies: motor areas received actual information about the goal in by signals in non-standard time direction.

Time mirror hypothesis allows to understand these anomalies. The sensory percept corresponds to one end of CD and its second end corresponds to an action determining motor action as a reaction to the sensory percept. What is remarkable that a lot of processing could be done in geometric past since the signal could continue to the MB of geometric past.

One could also consider an alternative explanation. In TGD framework directed attention would correspond generation of magnetic flux tubes connecting boxers and making possible entanglement and sharing of mental images making possible telepathy. This could be tested: do mirror neurons react to actual motor actions (telepathy) and to a video about motor actions (no telepathy) in a similar manner.

There are also other objections against mirror neuron hypothesis.

1. One can argue that mirror neurons must learn to act as mirror neurons during the development of individual. There is however a problem: a new-born infants can mimic gestures although she has never seen them earlier. One explanation would be that these gestures correspond to fixed action patterns, innate and instinctive behaviors coded by genes.

   What about the situation in TGD framework. The first explanation would be that brain regions of infant direct their attention to the sensory areas considered. This is however more like learning.

   Second explanation would be genetic. One can say that genes code for the 4-D preferred extremals represent magnetic bodies and serve as templates for biochemistry. A basic hypothesis is that DNA and other basic biomolecules are accompanied by parallel flux tubes carrying sequences of dark protons - dark nuclei - realizing also genetic code and communicating between themselves using dark photon triplets - kind of 3-chords for music of light - realizing genetic code too [L1, L16].

   In this picture one could say that dark genes at the MB of DNA associate/code for ordinary genes in turn coding for the biolochemistry of the ordinary biomatter. This would be in accordance with the vision that bio-chemistry is controlled and induced by MB acting as boss and having larger value of h_{eff} and thus higher "IQ".

2. There are also problems with adaptation. Mirror neuron hypothesis in its original form predicts that there should be a complete symmetry between sensory and motor sides. Also adaptation should be completely symmetric. In the experiments [J9] (see `http://tinyurl.com/y7jqljwv`) adaptation to motor actions, which were performed and then observed or vice versa. Four cases were studied. Motor actions were repeated, motor actions were repeatedly perceived, motor action was first observed and then carried out, and motor action was first carried out and then observed.

   In the first two cases adaptation was observed. Also in the third case as one expects also in the case that association between sensory percept and motor action is in question. In the fourth case adaptation was not observed and this does not conform with mirror neuron hypothesis. It was however later found that the situation is symmetric in the case of goal directed action.

   In TGD framework the result can be understood if only goal directed actions involve the pairing between its sensory percept and realization and assignable at opposite boundary of CD. This of course is very natural definition of goal directed action.

3. At F_5 premotor regions of monkeys there many neurons, which do not act as mirror neurons in the sense that they would respond to a perception of goal directed motor actions. For instance, there are neurons firing for graspable objects alone. Could the mere sensory percept induce an imagined motor action - grasping the object. Is this sensory-motor association or analog of mirror neuron activity?

   What about the interpretation in TGD? Is sensory-motor association in question or do the boundaries of CD represent the percept of a graspable object and the act of grasping. If the mirror neurons have learned to direct their attention to the sensory neurons active when the motor action induced by them is perceived, one could interpret the situation in terms of time mirror hypothesis. One might also argue that in the case of static perceptions there is no compelling reason for fast reactions so that sensory-motor association could be enough.

4. According to [J6], "*Despite its widespread acceptance, the proposal has never been adequately tested in monkeys, and in humans there is strong empirical evidence, in the form of physiological and neuropsychological (double-) dissociations, against the claim.*". These dissociations would mean that time mirror relationship is not present. As noticed, this relationship is in principle dynamical if generated by directed attention mediated by flux tube connections.

4 The findings about entrainment of the speech regions of right and left brain

The starting point was the popular article (see `http://tinyurl.com/y8a4puca`) telling about the findings of David Poeppel and his student Florencia Assaneo [J5] (see `http://tinyurl.com/y79r62v9`). The basic question inspiring their work was could be put as "*How sound waves put ideas into your head?*". The answer provided by their would can be phrased as "*Brain waves surf on the sound waves*". This work relates also to mirror neuron idea but mirror neurons are not mentioned in the article and Poeppel is critical about mirror neurons in his article [J4] discussed briefly in the introduction.

4.1 Findings

The basic characteristic of the speech is the frequency with which the loudness of speech changes. This frequency is determined as the average rate for syllables. This rate various in the range 2-7 Hz for comprehensible speech. Speech regions entrain to this frequency in the range 2-7 Hz The average frequency of entrained signals in auditory cortex is commonly about 4.5 Hz, which is also the men rate at which syllables are spoken in various languages.

In the experiments Assaneo studied people listening non-sense syllables (to avoid indirect effect on motor areas) with rate varying in the range 2-7 Hz. The idea is that if brain waves in auditory cortex are not independent on those in speech motor cortex they should entrain. This indeed occurred but only up to 5 Hz (theta waves are in the range 4-7 Hz and mu waves in the range 7-12 Hz) . At higher frequencies speech waves dropped out of synchrony. A computational model allowed to verify that this finding is consistent with the assumption that speech motor cortex has its own internal oscillator driven with a frequency in the interval 4-5 Hz. There was also a resonance around 4.5 Hz.

Neural model for the finding was based on a model known as Wilson-Cowan mean-field approximation treating excitatory and inhibitory neuron populations in speech motor region as competing synchronous units driven in non-linear manner by the oscillatory input from the auditory regions. Auditory region drive motor-cortex region with a periodic force. The time constant for the oscillations telling how fast they attenuate exponentially in absence of driving force was 60 ms, which happens to be also the reaction time of boxers mentioned earlier and could be assigned with mirror neurons.

The non-linear driving force was taken to be sigma function approaching value 1 for large positive values of the argument (saturation) and to zero for small values of the argument. The argument of sigma function was taken to be sum of various inputs excitatory and inhibitory inputs with opposite sign, background contribution, and the periodic driving force. For large enough amplitudes oscillatory input the positive part of the signal gives a considerable input whereas the

negative part is cut away. Therefore the system responds essentially to the syllables but not to the silent periods between them.

4.2 TGD based model

Could the finding of Poeppel and Assaneo be understood in terms of the time mirror mechanism? If so, motor speech regions and auditory regions would be in time mirror relationship - motor regions would attend the sensory regions and vice versa. The speech motor response - realized as imagined, inner speech - would in standard time direction appear before the sensory input and be due to the communication by negative energy signals. Maybe this could be tested by using sharp enough pulses as sensory input. The periodic appearance of the syllables is however expected to mask this effect unless one uses different syllables.

In TGD framework speech regions would communicate to a layer of MB with cyclotron frequency which $E_{g,J}$ and generate a resonant response in opposite time direction with this frequency in turn inducing resonant firing at the speech regions. Neuroscientist would assume resonant interaction of brain hemispheres using nerve pulses.

One can make this model more concrete if one accepts the vision about MB as receiver of sensory input from neuronal membranes as Josephson radiation with Josephson energy $E_J = ZeV$ and scaled down Josephson frequency $f_J = ZeV/h_{eff}$. A more general model [K8, K4, K11] assumes generalized Josephson energy supported by the basic facts about nerve pulse generation given by

$$\begin{array}{ll} E_{g,J} = \Delta E_c + E_J = h_{eff} f_{g,J} \ , & f_{g,J} = \Delta f_c + f_J \ , \\ f_c = \frac{ZeB_{end}}{2\pi m} \ , & f_J = \frac{ZeV}{h_{eff}} \ , \\ E_c = \hbar_{eff} \frac{ZeB_{end}}{m} \ , & E_J = ZeV \ . \end{array} \tag{4.1}$$

The generalized Josephson frequency is identified as a sum for the difference of cyclotron frequencies at two sides of the membrane and of the scaled down Josephson frequency. The assumption that scaled down Josephson frequency gives a small perturbation to the dominating difference of cyclotron frequencies and codes nerve pulse patterns as small modulations of $f_{g,J}$. One can however consider also a situation in which only f_J is present.

Here Z and m denote the mass and charge of the charged particle, say ion, or of corresponding Cooper pair, forming cyclotron Bose-Einstein condensate. One has $h_{eff} = n \times h_0$, where h_0 is the minimal value of h_eff and $h = 6 \times h_0$ is the most reasonable estimate for h found hitherto. There are two conditions on the model. The condition that $f_{g,J}$ is 4.5 Hz and the condition that $E_{g,J}$ is in visible and UV range.

The frequencies $f_{J,g}$ at cell membrane and f_c at MB should be roughly the same in resonance. In the applications the "endogenous" magnetic field B_{end} is assumed to have the minimal value $B_{end} = .2$ Gauss, 2/5 of the Earth's magnetic field. B_{end} is with inspiration coming from the p-adic lengths scale hypothesis [K10] assumed to have a spectrum spectrum consists of similar octaves with the frequencies in a given octave corresponding roughly to the spectrum of possible notes in music experience.

1. The expressions

$$E_{g,J} = \frac{n}{6} \frac{Ze\Delta B_{end}}{2\pi m} + ZeV \ , \quad f_{g,J} = \frac{Ze\Delta B_{end}}{2\pi m} + ZeV \ , \tag{4.2}$$

allow to estimate the value of h_{eff} and ΔB_{end} for given Z and m. For the membrane voltage one can use the estimate $eV \simeq .06$ eV. $f_{g,J} = 4.5$ Hz gives one constraint. The condition that the dark photons involved transfrom to bio-photons with energies in visible and UV range gives second constraint. The condition that $E_{g,J}$ is at the lower limit of visible energies gives $E_{g,J} = 1.65$ eV.

The cyclotron frequency for Ca^{2+} in $B_{end} = .2$ Gauss is 15 Hz and from Z/A scaling one can express the cyclotron energy for ion (A, Z) or Cooper pair with mass $(2A, 2Z)$ as $E_c(A, Z) = (20/A)E_c(A, Z) = (20Z/A) \times 15$ Hz. Signalling between hemispheres using radiation along short flux tubes connecting them is not of course excluded.

2. The hypothesis $\hbar_{eff} = nh_0 = \hbar_{gr} = GM_D m/\beta_0$ is central piece of TGD inspired quantum biology. $h = 6 \times h_0$ is the most plausible possibility. h_{gr} is the gravitational Planck constant introduced by Nottale [E1] and M_D corresponds to large dark mass and β_0 is a parameter with dimensions of velocity: for a detailed discussion see [L11]. The hypothesis implies that $h_{eff} \propto 1/A$ where A is mass number of ion so that cyclotron energies do not depend on mass of the ion and are universal. Josephson frequencies would scale like $f_J \propto 1/A$ and cyclotron times as $\tau_J \propto A$. Different ions would be at flux tubes with different value of $h_{eff} \propto A$.

3. Comorosan effect corresponds to a universal biorhythm of 5 seconds [I5, I1] and recently it was found to relate to the clustering of RNA polymerase proteins in the transcription of RNA [I2] (see `http://tinyurl.com/y9wzt5yl`). The origin of Comorosan effect is not understood, and I have proposed [K18] that it relates to Josephson effect at the level of biomolecules in bio-catalysis. In [L12] I developed a model in which proton's Josephson time for proton in Josephson junctions involved with bio-catalysis equals to 5 s.

   If the cyclotron frequency $f_c = 300$ Hz of proton for $B_{end} = .2$ Gauss corresponds to bio-photon energy of x eV, one obtains in the case of proton the condition [L12]

   $$r = \frac{h_{eff}}{h} = \frac{\hbar_{gr}}{\hbar} \simeq .83 \times 10^{12} x \quad .$$

   If cell membrane potentials are Josephson junction consistent with the model, the Josephson times for ions with mass number A would be $\tau_J = A \times 5$ seconds. These scales would obviously correspond to the scales of conscious experience. The cyclotron energies would not depend on the mass number at all. If the spectrum of bio-photon energies has lower bound at the end of visible spectrum at 1.65 eV one has $x = 1.65$ as a natural first guess.

4. One can look for cyclotron frequencies for ions for $B_{end} = .2$ Hz. The frequencies $f_c \in \{4.0, 4.5, 5.0\})$ Hz corresponds to atomic weights $A \in \{75, 67, 60)\}$. Josephson times would be for the above model of Comorosan effect given by $f_J(A) = A \times 5$ seconds. This gives the following table containing data also for iron for which cyclotron frequency is rather near to 10 Hz in alpha band.

ion	A	f_c/Hz	τ_J/s
Cu	63	4.8	315
Zn	68	4.4	340
Se	74	4.1	370
Fe	56	10.3	280

   (4.3)

   Josephson times are rouhgly between 5 and 6 minutes for Cu, Zn, and Se. The differences of cyclotron frequencies are expected to have same order of magnitude and therefore also corresponding energies for bio-photons.

   If one assumes that the energies are in IR but above thermal energy of photon at physiological temperatures the scales of cyclotron energies and Josephson times are reduced by a factor $\sim 1/50$: $x \to x/50$. For Fe one would obtain $\tau_J \sim 5$ seconds, which happens to be Comorosan time again.

5. The part of MB associated with motor regions controlling speech receives information at these EEG frequencies and sends control signal, which do not propagate down to speech muscles except in some special cases. Note that the size scale of this layer of MB is from the condition that cyclotron wavelength gives the size scale of MB roughly 1.7 times the circumference of Earth from Schumann frequency 7.8 Hz.

6. The prediction is that right and left speech regions are not conscious simultaneously. Auditory experience is not possible when one speaks or even when internal speech is present. This can however happen only in the time scale defined by the duration of syllable and would be of the order $1/2f \sim .11$ s defining the lifetime of sub-self and its time reversal as duration of syllable. This is roughly the estimated duration $\sim .1$ s of sensory mental image mentioned

earlier. Syllable perception corresponds to quantum coherence and synchrony at auditory areas. The real motor action - rather than motor region at the moment of generation of motor action - corresponds to loss of quantum coherence and synchrony at speech motor regions.

5 TGD based model for sensory long term memories

There was a highly interesting popular article (see `http://tinyurl.com/yaopecrh`) inspired by the recent findings about long term memory [J3] in an experiment carried out by Timothy Brady, Talia Konkle, George Alvarez, and Aude Oliva (see `http://tinyurl.com/y9yessmr`). The findings are in conflict with the standard view about memories. Of course, also the memory feats of so called idiot savants known for decades are in sharp conflict with the standard view about memory.

The discussion of these findings in TGD framework led to a decisive improvement in the understanding of the proposed mechanism of sensory memory recall. Also a connection with the model of topological quantum computation [K1, K16] realized axon-microtubule level emerged. Sensory memory would be realized as a topological quantum computer program running in reversed time direction in memory recall and generating the virtual sensory input from brain to sensory organs creating the original sensory experience.

5.1 The findings

The following gives a brief summary of the results of the [J3] experiment discussed in the popular article.

1. A huge amount of storage capacity is required and it increases as more and more experiences are experienced. One can imagine an abstraction as a cure: store only essentials about the input. This is extremely powerful manner to store the relevant information. Picture about grandmother's house with all detail is replaced with world "grandmother's house". What is lost is detail. This storage mechanism is certainly used at higher levels of evolutionary hierarchy. Verbal memories are a good example.

   The experiment mentioned above however demonstrates that the memory storage is at least 1000 times more detailed than it could be, which suggest that a different very detailed storage mechanism usually unconscious to us is involved.

   Indeed, the memory feats of idiot savants show that sensory percepts can be stored in amazing detail. A possible TGD based explanation is that all of us have sensory memories - essentially re-experiences but at a lower level of personal self hierarchy, not as mental images represented as sub-selves but as sub-sub-..-selves not directly conscious to us. Temporal democracy would make it impossible to distinguish between recent and past and make it difficult to survive. Here would be the reason for why these persons are often called idiot savants.

   Sensory memories must be unconscious at our level of self hierarchy to allow the experience about living in definite moment of time and only cognitive (symbolic, verbal) memories involving a lot of abstraction satisfy this condition. If the percept is cognitive, it is about geometric past. If sensory, it is about "Now". Perceptive field effectively reduces from 4-D to 3-D (actually the duration of sensory chronon is about .1 seconds).

   Situation changes when temporal lobes are stimulated electrically as neuroscientists have known for decades but "forgotten". Perhaps animals do not conceptualize and have sensory memories.

2. Proteins used for the storage in terms of modified synaptic contacts is slow by a factor 1000 slower than required to understand the above experiment. Memorizing would require a repeated stimulation but now the pictures were seen only once or twice.

3. The lifetime of the proteins in synaptic contacts is only few weeks so that also long term memories would be unstable. Humans can remember for about 50 years, 1000 times longer than expected.

4. The technical realization of the 3-D storage is also a problem. One should remember also the place, where the memory is stored, not only the memory itself! Here the association mechanism seems the only possibility but would allow only conditionings. In computer language LISP this idea is very concretely realized. Conditionings are however only pseudo-memories.

5.2 Wrong views about time and the notion of memory as the basic problems

To sum up, the standard view about memories suffers from two fatal problems.

1. The first fatal problem of the standard model of memory is the wrong view about the relationship between experienced and geometric time. The identification of these times forces to the notion of memory storage analogous to that in computer. The information about what happened must be stored again and again. This view has many problems already discussed.

2. Second fatal problem is the conceptual flaw forced by behaviorism: memories are identified as conditiongs, habits, or behaviors - as you like. Genuine sensory memories are however re-experiences and would however correspond to re-experience to which is associated a synchronously firing neuron group: what neurons fire is not determined by synaptic contacts but by the sensory input mapped topographically to sensory area. This is very delicate and crucial difference.

5.3 TGD view about sensory memories

Could one realize memory as re-experience in TGD framework?

1. In zero energy ontology (ZEO) of TGD *no* 3-D memory storage to the "brain now" is required. Memories are ideally where (in 4-D sense) the event occurred but memory recall creates further - usually less detailed and more abstracted copies - of the memory [K12] [L17]. To remember (in the genuine sense of the word) is to re-experience. Memory in this sense would be in the geometric past. Memory recall would be seeing in time: sending a signal to geometric past, where it is time-reflected back. Each memory recall could generate at least a conceptual copy about the memory and in this manner the signal sent to the geometric past would have higher probability to generate the re-experience or at least secondary version of it. Learning, which is not mere conditioning, could rely on the generation of copies of the memory in 4-D perceptive field.

2. Memories as re-experiences would involve synchronously firing neuron groups associated with quantum coherent units defined by magnetic bodies (MBs) of neurons and representing mental images. To understand this concretely, one needs besides the notion of MB also the hierarchy $h_{eff} = n \times h_0$, $h = 6 \times h_0$ of Planck constants. The synchronously firing neuron group (involving quantum coherent part of MB) in the geometric past is woken up by the time reversed signal to the geometric past and reflecting from it by providing energy (now negative). ZEO makes this possible.

3. How the memory recall could realize this synchronous firing in the geometric past? This mechanism should be analogous to the reflection of negative energy signal in time direction from the brain of the geometric past. ZEO allows sending of a negative energy signal travelling to geometric past. It should somehow induce a transition generating the synchronous firing. The signal generating this transition should be very simple. It must induce the transition at correct location in the geometric past. Here the period of the carrier wave of the signal could be essential and large value of h_{eff} could make the signal energetic enough despite the period which could be measured in years so that energy for the ordinary value of Planck constant would be extremely small. Signal could also provide metabolic energy for the neurons, which should fire synchronously. Replicas of the memory help to achieve activation at the correct location.

4. There must be a coding of the sensory input to the physical state of neuronal pathways coded by nerve pulse patterns representing the original sensory input from the sensory organs. If genuine sensory re-experience is required a signal generating the original sensory experience and thus the nerve pulse pattern from sensory organs creating it should be re-generated.

   As if one had in the geometric past a magnetic tape representing somehow the original experience. When played it would generate a signal to the sensory organs in turn generating the signal to the brain (including nerve pulses) giving rise to the original sensory experience. Note that ZEO indeed allows the sensory experience to be in geometric past. It is however communicate cognitive information about it to recent too.

TGD leads to a model for what could happen based on the idea that topological computation is realized in terms of the braiding of magnetic flux tubes connecting two subsystems [K1, K16](see `http://tinyurl.com/yawk2x4t` and `http://tinyurl.com/y9z499a6`). This model leads to a model of memory representations as a kind of topological quantum computer program giving the original experience as an output while running.

Let us assume that second system is axonal membrane along which the nerve pulse patterns (and whatever else is needed) representing the sensory input flow. Second system would be naturally microtubules inside it.

1. The flux tubes would connect the lipids of the axonal membrane to the tubulins (or units formed by them). Axonal membrane can be in liquid-crystal state meaning that the lipid are like liquid particles able to move. Nerve pulses would induce a 2-D liquid flow inducing the braiding of the flux tubes having second end fixed to (say) tubulin of the microtubule.

   There would be both time-like and space-like braiding. Dance metaphor is very helpful here. Consider dancers at the parquet with legs connected by threads (flux tubes) to a wall (microtubule). Time-like braiding would correspond to the dynamical dance pattern of lipids in time direction having a representation as a 2-D projection defined by the paths of dancers at the parquet. Time like braiding would be analogous to a running topological quantum computer program.

   Space-like braiding would be the outcome of the dance representing tangle of the flux tubes fixed to the wall and defining topological quantum computer program serving as a representation for the time like braiding and therefore also for the nerve pulse pattern (and whatever the signal involves) and the sensory input. Space-like braiding is analogous to the code representing the topological quantum computer program and should make possible to represent the program.

   If this space-like braiding can generate a signal serving as a virtual sensory input to the sensory organs, the sensory memory could be regenerated. The running of the topological quantum computer program would mean the opening/un-knotting of this braiding and would represent the time reversal of the sensory input, not yet sensory input, which could correspond to nerve pulse pattern from the sensory organs generating the sensory percept. It seems that the opening must generate a signal to sensory organs as virtual sensory input.

2. Virtual sensory input brain indeed is the basic element of TGD inspired model of sensory perception as construction of artwork [L5] (see `http://tinyurl.com/yczv2o5b`). The basic difference to the standard view is that the sensory qualia are at the level of sensory organs rather than in brain. Brain only gives names for the percepts and builds standard sensory mental images by using virtual sensory input from brain. The process is like pattern recognition by driving sensory input to a standard input near to the real input.

   In TGD framework however nerve pulse patterns would not carry the sensory information to the brain but would generate sensory input to MB as Josephson radiation from the cell membrane. The transmitters emitted at the synaptic contacts would generate bridges connecting axonal magnetic flux tubes to longer connected flux tubes and in this manner create the communication channels - kind of wave guides. Along thee dark photons (which can transform to bio-photons) could travel with light velocity.

   This communication mechanism is dramatically faster than the communication by nerve pulses and allows forth-and-back signalling involving virtual sensory input from brain to

generate the standard percepts assignable to the synchronously firing neuron groups accompanied by magnetic bodies obtained by connecting neuronal magnetic bodies by flux tubes.

The standard mental images would contain only the features relevant for survival or otherwise interesting. A still open question is whether the virtual sensory input corresponds to the time reversal of the ordinary sensory input [L17] (see `http://tinyurl.com/ybe4vf3j`). The following consideration suggests that time reversal is indeed in question.

3. If the virtual sensory input from brain to sensory organs is dark photon signal in time reversed time direction, one can think of very simple model for memory as re-experience. In ZEO based view about conscious entities "big" state function [L10] would occur meaning that the mental images associated with braiding generated by nerve pulse pattern and dark photon beam die and re-incarnate in opposite time direction. A time-reversed mental image would be generated. This mental images is not conscious at our level of hierarchy living in opposite time direction.

   This mental image is not quite exact time reversal of the original and there is non-determinism of state function reduction involved. One can have however statistical determinism possible if large enough number of neurons are involved. Therefore the differences need not be too big. Also standardization comes in rescue: it would take care that the sensory mental is very nearly the counterpart of the original.

   The time-reversed signal from brain to the sensory organ should generate a nerve pulse pattern just as in the case of ordinary perception and the dark photon signal generating the sensory mental image defining the original sensory memory in good approximation.

4. For the simplest alternative dark photons alone induce the flow of the lipids. Hitherto it has been assumed that the flow is induced by nerve pulse patterns. The most general option is that both are involved in the generation of the flow. One cannot exclude the possibility that the communication of data about nerve pulse pattern to MB generates a control signal which induces the liquid flow. There are many options to consider but the basic idea is clear and involves ZEO and MB in a crucial manner.

5. An important open question is whether the virtual sensory input using dark photons propagates

   (a) to the "sensory organs then" so that only cognitive memories would result as copies. In this case a person, who has lost eyesight during lifetime could have visual memories from time when she could see.

   (b) or via the MB to the "sensory organs now" and stimulates sensory experience in "brain now". Person lost eyes during lifetime could not have visual sensory memories in this case.

   For the latter option one can ask whether the sensory experience is

   (a) realized by the mere virtual sensory input to sensory organs. No copies of the sensory representation at the microtubule-axon level would be generated. If sensory organs are not intact, sensory memories would not be possible.

   (b) or whether also a signal from sensory organs to brain involving nerve pulse pattern is needed to generate the experience. Each memory recall would create an almost exact copy of topological computer program giving rise to a genuine sensory memory while running.

   Various options might be tested by electric stimulation of the temporal lobes known to generate sensory memories.

6 Are basic biochemical processes induced by topological quantum computer programs running in non-standard time direction?

The basic bio-chemical processes such as replication, transcription, translation have remained mysteries in standard biology. My conviction is that a lot of new physics is needed. Bio-chemistry is not enough, even QFT is not enough. Even standard views about space-time and classical fields, QM, and basic ontology are not enough.

TGD approach indeed brings in several new physics elements.

1. The notion of magnetic body (MB). MB carrying dark matter identified as dark variants of charged particles having non-standard value $h_{eff} = n \times h_0$ of Planck constant is central in TGD inspired quantum biology. MB is the intentional agent receiving sensory input from biological body and controlling it. The interactions at the level of ordinary bio-matter would be governed by the MBs of molecules, and bio-chemistry would be a shadow of this much simpler dynamics.

   MB of water entrains to the cyclotron frequencies of the MBs of the basic biomolecules by varying flux tube thickness. This makes possible water memory [L13] (see `http://tinyurl.com/y9mr9s2w`) and implies homeopathy like mechanisms serving as basic quantal building bricks in the functioning of the immune system. Dark variants of DNA, etc.. realized as dark proton sequences would be one aspect of this representation.

2. The braiding of the magnetic flux tubes makes possible realization of topological quantum computer (TQC) programs. Biological functions should correspond to TQC programs and the challenge is to understand how they emerge naturally. A possible answer to this question will be proposed in the sequel.

3. There are also other central notions such as zero energy ontology (ZEO) predicting that the arrow of time is not fixed. The following arguments suggests that ZEO is absolutely essential for the understanding of the miracles of bio-chemistry. TQC programs running *backwards in time* would generate as output various biological functions such as DNA transcription and other basic processes.

6.1 What are the big problems?

It is best to start from the problems that one should solve. At bio-molecular level the basic problem is to understand how complex temporal sequences of bio-chemical reactions involving bio-catalysts are possible as highly deterministic sequences.

1. How the reacting molecules - including catalysts - are able to find each other in the molecular soup?

   TGD answer: Contraction of flux tubes connecting molecules very selectively as h_{eff} is reduced brings molecules together. Connections between molecules are generated by re-connection of U-shaped flux tubes scanning enviroment and producing pair of flux tubes connecting the two systems provided they have the same cyclotron frequency. Resonant em coupling by dark photons is in question.

2. How the attached molecules are able to attach to just the correct spot and orient just in the correct manner?

   TGD answer: the contraction mechanism for flux tubes automatically guarantees also this.

3. How the rate of reaction can exceed the expected rate by so huge factor?

   TGD answer: Reactants are connected by flux tubes so that the probability that they find each other is much higher and depends on the occurrence of h_{eff} reducing transition which occurs spontaneously. The energy liberated in the contraction of flux tube allows to overcome potential wall in the reaction and exponential increase in the rate is achieve.

4. How bio-catalysis can proceed in time ordered manner like deterministic computer program so that very many initial states can lead to the same outcome?

   Here the initial states would correspond to positions orientations, etc of input molecules. Huge number of initial states lead to the same outcome.

   I think that this is the really difficult question. I am highly skeptic about the possibility to understand this in QFT framework. In the following I propose TGD inspired solution of this problem requiring ZEO, which means a revolutionary modification of basic ontology and of views about time.

6.2 Basic biological processes as TQC programs

Apparently a breaking of second law is involved. Very many initial states lead to the same outcome rather than vice versa. As if the process would be controlled by the time reversal of the original process and entropy would increase but in opposite time direction as usually but at the control level! The notion of syntropy introduced by Fantappie comes in mind!

TGD answer would involve at least the following pieces.

1. Dark DNA and dark variant associated with enzyme should be part of the story. Large h_{eff} brings in conscious information realized as algebraic complexity and large scale quantum coherence.

2. ZEO allowing time reversed processes should be essential. ZEO predicts both directions of time and motor actions are postulated to correspond to sensory perception in opposite arrow of time. What this precisely means is not however clear.

3. Magnetic body (MB) should be the boss controlling dynamics. This dynamics should be very simple. Biochemistry should be shadow dynamics and apparently extremely complex.

4. Topological quantum computational (TQC) [K1, K16] is also a central aspect but I have not been able to articulate what TQC programs are and how they would emerge: the following ZEO arguments suggests an astonishingly simple solution to both problems.

   The complex reaction sequences like transcription should correspond to a running of topological quantum computer (TQC) program coded by the braiding. The proposed realization of sensory memories serves as a guideline. Memory recall would be like a quantum computer program running backwards in time and producing sensory experience as output.

   There is a strong temptation to believe that this is completely general aspect of all also motor actions. By fractality also DNA transcription, translation, etc... are analogs of motor actions. Somehow they should be coded to TQC programs realized as braidings of flux tubes of MB.

   The output of the TQC program running *backwards* with respect to the standard direction of time would be motor action as we observe it. All basic bio-processes involving several steps be coded to braidings. One can imagine a hierarchical structure: programs, subprograms, etc... for the TQC programs. Braidings of braidings of.... This conforms with the hierarchical many-sheeted structure of space-time.

How to realize motor actions as outputs of TQC programs running in non-standard direction of time?

1. Assume that when some process - such as DNA transcription or its time reversal occurs - it induces braiding of flux tubes - topological quantum computer (TQC) program at the level of MB. The braiding flux tubes connecting systems of ordinary matter as they move would automatically generate the TQC program representing the motion as a motor action.

   As this TQC program runs backwards in time, the *time reversal* of the original process is generated as output at the level of ordinary bio-matter - inverse braiding in the previous example. The running in reverse time direction would follow a “big” state function reduction for the quantum system defined by the flux tubes inducing time reversed motion (meaning death of this sub-self and reincarnation in opposite time direction). The interaction with

ordinary matter system living in ordinary time direction and corresponding to different values of h_{eff} would serve as a template for the dynamics of ordinary matter forcing it to obey time reversed dynamics.

2. For instance, in the case of transcription, one should assume that the time reversal of transcription meaning the decay of mRNA back to its building bricks generates the TQC program as braiding of flux tubs. Running of this TQC problem in the reverse time direction should generate transcription and bio-chemical level.

3. The sub-..-self corresponding to the TQC program is lost only temporarily in the process. A death and re-incarnation of time-reversed self creates the program in the original time direction but the corresponding CD has increased in size. Are all sub-CDs/TQC programs conserved or can they disappear? Also disappearance is in principle possible if zero energy state associated with CD is not orthogonal to a tensor product of vacuum states associated with its opposite boundaries.

4. What looks strange that the time reversal of the assembly process - essentially a decay process occurring in very ways - would code for the highly deterministic TQC program for the assembly process. But this is actually just what one wants!!

   The decay process is highly unpredictable but its time-reversal is highly predictable! There are very many TQC programs, which give rise to the desired output! The ways from Rome lead to all possible directions but all ways lead to Rome! In ZEO butterfly effect transforms to extreme predictivity in opposite time direction!

5. Also the standardized sensory percepts discussed in the model of sensory memory could be seen as TQC programs generating as an output standardized sensory mental image nearest to the actual sensory input. The propagation of bio-photons forth-and-back between sensory organ and brain would generate this standardized mental image. Is sensory memory just a motor action at the level of ordinary matter generated by the time-reversed signal to geometric past identifiable as TQC program running backwards in time? As a matter of fact, there should be no difference between sensory memory and sensory percept in 4-D sense.

6. How MB and space-time sheets assignable to ordinary matter and having opposite arrows of time - or more generally two levels of h_{eff} hierarchy with different values of h_{eff} and different arrow of time - could interact? If the arrows of time are opposite, the intersection of space-time sheets should have dimension smaller than $D = 4$. Since the classical dynamics determined by twistor lift breaks T symmetry (the analog of Kähler action in M^4 degrees of freedom is the reason), 3-D intersection does not imply that the surfaces co-incide for the space-time surface and its time reversal.

   The interaction should be via common boundary conditions: the space-time sheets with different arrow of time should intersect along 3-D or even lower-dimensional surfaces at the boundaries of CD and perhaps also at the 3-D light-like orbits of partonic 2-surfaces at which the signature of the induced metric changes. Magnetic flux tubes induce braiding, which suggests that magnetic flux tubes of MB as 4-D surfaces should have at most 3-D intersection with the space-time surfaces representing ordinary bio-matter and defining the nodes of tensor network [L4]. These 3-D - possibly light-like - intersections would mediate the interaction. For the usual arrow of time for MB the interaction would be sensory input to MB and induce braiding. For the opposite arrow of time for MB it would be motor action in which MB would be the controller forcing bio-matter to follow in the un-braiding process.

   In the generic case the intersection of two 4-surfaces in $M^4 \times CP_2$ is discrete. Could the intersection of space-time surfaces with different arrow of time consist of a discrete set of points? Could this be enough for MB to control bio-matter? Note that cognitive representations identified as intersections of real space-time surfaces and their p-adic variants consist of a discrete set of points [L6].

7. The connection with Sheldrake's vision about morphogenetic fields, in particular the generation of "habits" even at the level of so called dead matter [I3, I4] is rather obvious. TQC

programs would indeed code for habits and would be generated by Nature without a need of a programmer writing the code. I have discussed Sheldrake's vision from a slightly different viewpoint in [L3].

There are interesting connections to ancient Indian philosophy and Christianity. ZEO has analog in ancient Indian philosophy as I learned from a discussion with Savyasanchi Ghose while writing this. As notions doer and un-doer are analogous to self and time reversed self. MB would be in the role of supreme observer although it would not be outsider to the Universe. The undoing the time reversal of deed by MB would serve as a template for the dynamics of deed at the level of ordinary matter.

Building braids and opening them are indeed the basic operations in TQC according to ZEO. A visit to web using "undoer" reveals that it appears also in Christianity, Mary the undoer of knots! Knots are now a metaphor for sins and undoing them means mercy. In Christianity God would be the counterpart of MB and we would be 4-D dynamical images of God.

To sum up, this sounds like mystics and brings strongly in my mind a french movie about time that I saw decades ago. It was very poetic and somehow caught at the emotional level something very deep about the mysteries of time, life, and consciousness in a way not expressible using the vocabulary of scientist. It seems that TGD is providing the language that I did not have at that time and that ZEO is starting to demonstrate its magnificent explanatory power.

7 Three findings about memory recall and TGD based view about memory retrieval

I received within few weeks 3 highly interesting links telling about the work of neuro-scientists relating to memory recall. This inspired a construction of a detailed model for the memory recall which generalizes to a model of sensory perception and motor action based on the vision discussed in detail in [L17] (see `http://tinyurl.com/ybe4vf3j`). The original vision about motor action as time reversal of sensory percept is sharpened so that motor action corresponds to a "big" state function reduction (BSR) changing the arrow of time and sensory percept to "small" state function reduction (SRS) preserving it. What is also new, is the combination of this picture with the old TGD based vision [K3] about living system as a conscious hologram. The idea about brain as hologram is originally due to Karl Pribram [J7].

A short summary of TGD inspired theory of consciousness is in order to help the reader to follow the arguments.

1. Zero energy ontology (ZEO) predicts that quantum states are superpositions of deterministic time evolutions (preferred extremals representing space-time surfaces as minimal surfaces). These space-time surfaces connect 3-surfaces the opposite boundaries of causal diamond (CD) forming a scale hierarchy. There are two kinds of state function reductions.

   Zero energy states can be regarded as pairs of ordinary quantum states located at opposite boundaries of CD and having interpretation as wave function in the space of 3-surfaces at the boundary of CD. The 3-surfaces at opposite boundaries of CD are connected by space-time surface - preferred extremal - which is minimal surface apart from 2 dimensional string world sheets and their 1-D light-like boundaries at light-like 3-D orbits of partonic 2-surfaces at which the signature of the induced metric of space-time surface changes its signature from Minkowskian to Euclidian [L19, L18].

   "Small" state function reductions (SRSs analogous to weak measurements in standard quantum measurement theory) leave the passive boundary of CD unaffected as also states at it but affect the states are active boundary, and also shift the active boundary farther away from the passive one (in statistical sense at least). Each small state function reduction is preceded by a unitary evolution of state at the active boundary meaning shift of the active boundary: actually a time-delocalization of the active boundary takes place in the moduli space of CDs. SRS involves a localization with respect to time defined by the temporal distance between the tips of CD. The correlation between experienced time and geometric time identifiable as the distance between the tips of CD follows since state function reductions identifiable as basic building bricks of conscious experience increase this distance in a statistical sense.

"Big" state function reduction (BSR) changes the roles of the boundaries of CD and corresponds to state function reduction as it appears standard quantum measurement theory. In particular, the arrow of time as a property of zero energy state changes. The change of arrow of time is in a fundamental role in TGD inspired quantum biology and corresponds to the death of self followed by a re-incarnation with reversed arrow of time.

4. Since the superposition of preferred extremals is only replaced with a new one in state function reductions, they are consistent with the determinism of classical physics, which is an exact part of quantum TGD - space-time surfaces can be regarded as analogs of Bohr orbits. One also avoids the basic paradox of standard quantum measurement theory and there is no need for "interpretations".

5. The original somewhat fuzzy vision about motor action and sensory perception was as time reversals of each other so that the difference between them would be only relative. The recent view is more precise and implies absolute difference: Motor actions correspond to BSRs and sensory percepts to SRSs. Also memory recall can be seen as time reversal of sensory perception in a well-defined sense [L17].

The model for various findings described below relies on this picture combined with the vision about living system as conscious hologram [K3]. The TGD inspired model for for the memory recall generalizes to a model of sensory perception and motor action. The common mechanism of sensory perception, motor action, and memory recall would be surprisingly simple.

Magnetic body (MB) would send reference beams R interfering with incoming beams O representing sensory input to build a sensory representation as a hologram H on living matter serving as a substrate. Conjugate hologram $\overline{H}$ would correspond to a time reversal of H constructed using conjugate beams $\overline{R}$ and $\overline{O}$. The reading of sensory percepts/memories would take place by illuminating $H/\overline{H}$ with $R/\overline{R}$ coming from MB.

An important challengeable assumption is that the time reversals of our mental images are not conscious-to-us. It implies that the reading of the memory by $\overline{R}$ does not yet produce mental image conscious-to-us: only the next BSR would generate memory representation readable by applying R. This picture is consistent with the empirical findings inspiring the detailed model.

7.1 The findings

In the following brief summary about findings is given.

7.1.1 Ripples race in the brain as memories are recalled

The first link was to a popular article in *Science News* with title "*Ripples race in the brain as memories are recalled*" (see `http://tinyurl.com/y5hohv2h`) telling about the findings of neuroscientists Vaz *et al* about memory recall published in Science as article with title "*Coupled ripple oscillations between the medial temporal lobe and neocortex retrieve human memory*" [J1] (see `http://tinyurl.com/y48kdkrl`).

1. Results

The results come from the study 14 patients suffering from epilepsy. They had electrodes placed on their brains as part of their treatment. The electrodes also allowed scientists to monitor neural activity while the people learned pairs of words.

One to three minutes after learning the pairs, people were given one word and asked to name its partner. As participants remembered the missing word, neuroscientist and neurosurgeon Kareem Zaghloul and his colleagues caught glimpses of fast brain waves rippling across parts of the brain at a rate of about 100 per second.

These ripples appeared nearly simultaneously in two brain regions — the medial temporal lobe known to be important for memory, and the temporal association cortex having a role in language. When a person got the answer wrong, or didn't answer at all, these coordinated ripples were less likely to be present, the researchers found.

The abstract of the article provides a more technical summary.

Episodic memory retrieval relies on the recovery of neural representations of waking experience. This process is thought to involve a communication dynamic between the medial temporal lobe memory system and the neocortex. How this occurs is largely unknown, however, especially as it pertains to awake human memory retrieval. Using intracranial electroencephalographic recordings, we found that ripple oscillations were dynamically coupled between the human medial temporal lobe (MTL) and temporal association cortex. Coupled ripples were more pronounced during successful verbal memory retrieval and recover the cortical neural representations of remembered items. Together, these data provide direct evidence that coupled ripples between the MTL and association cortex may underlie successful memory retrieval in the human brain.

2. Ripples as hologram

The basic question concerns the interpretation of the ripples appearing both during the formation and the retrieval of the memory. The TGD based vision about living system as a conscious hologram [K3] suggests an answer (for the notion of hologram see `http://tinyurl.com/qgjsdzz`).

1. During the sensory perception the ripples are created by the interference of the reference beam coming from magnetic body (MB) with dark photon beam representing sensory input transformed to dark photons at sensory organs as TGD inspired model for the generation of percept as forth-and-back communication between MB/brain and sensory organs assumes [L14].

2. During memory recall MB sends the phase conjugate of the reference beam scattering from the time reversed conscious hologram and generates phase conjugate beam representing the time reversal of the sensory input. At quantum level this involves BSR and the phase conjugate mental image resides at boundary of CD opposite to that carrying the ordinary mental images.

   This sensory mental image need not be conscious-to-us and this has been the assumption. The "death" of the phase conjugate mental image in a further BSR gives rise to a mental image at the "normal" boundary of CD. This mental image need not be sensory mental image (sensory/episodal memory) and could correspond to imagination or verbal memory.

There are several questions to be answered. Can one keep the earlier hypothesis that the phase conjugate sensory mental image is not conscious to us? Does the "normal" mental image correspond to sensory mental image (episodal/sensory memory) or almost sensory mental image (declarative or verbal memory)?

7.1.2 The human brain works backwards to retrieve memories

The second interesting link was to an popular article "*The human brain works backwards to retrieve memories*" (see `http://tinyurl.com/y7hbqmug`). The article tells about the work of Linde-Domingo & Wimber *et al* published in Nature Communications as article titled "*Evidence that neural information flow is reversed between object perception and object reconstruction from memory*" [J8] (see `http://tinyurl.com/y375ht5f`).

1. Results

During the study, participants saw images of specific objects, and then learned to associate each image with a unique reminder word, for example the word 'spin' or 'pull'. The participants were later presented with the reminder word and asked to reconstruct the associated image in as much detail as possible.

Brain activity was recorded throughout the task via 128 electrodes attached to the scalp, allowing the researchers to observe changes in brain patterns with millisecond precision. Finally the researchers trained a computer algorithm to decode what kind of image the participant was retrieving at different points in the task.

The abstract of the article summarizes the results.

Remembering is a reconstructive process, yet little is known about how the reconstruction of a memory unfolds in time in the human brain. Here, we used reaction times and EEG time-series decoding to test the hypothesis that the information flow is reversed when an event is reconstructed from memory, compared to when the same event is initially being perceived. Across three experiments, we found highly consistent evidence supporting such a reversed stream. When seeing an object, low-level perceptual features were discriminated faster behaviourally, and could be decoded from brain activity earlier, than high-level conceptual features. This pattern reversed during associative memory recall, with reaction times and brain activity patterns now indicating that conceptual information was reconstructed more rapidly than perceptual details. Our findings support a neurobiologically plausible model of human memory, suggesting that memory retrieval is a hierarchical, multi-layered process that prioritises semantically meaningful information over perceptual details.

2. TGD vision

This picture is consistent with the general TGD vision predicting that memory recall and sensory perception differ by time reversal: it however turns that one must also assume that motor action corresponds to BRS and sensory perception to SRS. The picture is also consistent with an entire hierarchy of levels labelled by the values of effective Planck constant $h_{eff} = nh_0$ measuring roughly the level of evolutionary hierarchy [L9, L8] and by p-adic length scales. The larger the value of h_{eff}, the longer the relevant time and length scale is, and the more abstract the representation is. The "gist" would correspond to large values of h_{eff} to which one can assign largest maximum value of information content.

7.1.3 Neuroscientists read unconscious brain activity to predict decisions

The third link was to a popular article "*Neuroscientists read unconscious brain activity to predict decisions*" (see `http://tinyurl.com/yxgnr9x6`). The article tells about the work of Koenig-Robert and Person published in Scientific Reports as an article with title "*Decoding the contents and strength of imagery before volitional engagement*" [J11] (see `http://tinyurl.com/yyp6hugz`).

1. In the experiment the situation was following. The subject person looked at most $T = 20$ seconds two different pictures, decided to imagine either of them, and pushed immediately the knob. Then she tried to imagine the chosen picture. Subject person reported also the subjectively experienced intensity of imagination.

   Neural activity was detected in brain and it was found that it emerged $t = 11$ second before the decision. From the pattern of activity it was possible to predict the picture. Also the subjectively experienced intensity of imagination could be predicted. One could say that the sensory experience was re-created by imagination in the brain of past.

2. The imagination involved could be also regarded as an active memory recall. This interpretation suggests that the time t at which the neural activity appears must be within the $T = 20$ second interval during which the decision was made.

3. The authors leave open whether their finding excludes free will. The first interpretation is that the choice really occurred at unconscious level and for some reason subject person experienced illusion of choise. A real choice combined with illusion about real choice looks rather weird idea, and only shifts the problem of free will to a level unconscious to us. If there is no free will then all experiments involving choice are pseudo experiments: this would throw a large portion of neuroscience to trash bin.

These findings will be used to build TGD based model for memory recall based on TGD based vision about living systems described in the introduction.

7.2 TGD based model for what happens in imagination as active memory recall

The experiments discussed above give good hopes about a detailed model for what happens in imagination as active memory recall.

7.2.1 Background ideas

To develop this model some background ideas about TGD are needed.

1. I have developed a model for motor action as time reversal of sensory perception based on ZEO in an earlier article [L17] (see `http://tinyurl.com/ybe4vf3j`). This leads also to a model for remory recall as sending a signal to geometric past giving rise to time reflected signal as memory recall.

   Could memories correspond to mental images in standard time direction generated by time reflected dark photon beam as has been assumed hitherto or do they correspond to time reversed mental image in the geometric past at the opposite boundary of CD. The earlier assumption has been that time reversed mental images are not conscious to us.

2. There are several words to which one must give meaning: what do "re-experience in geometric past", "time reflection", "imagination as active memory recall" mean? Who is the imagining intentional agent? The above experiment inspired an attempt to give a more precise meaning for these words.

   The idea is to combine the model of memory with a decades old model of living matter as conscious hologram [K3] (see `http://tinyurl.com/y6lz3t3y`) (one more imprecisely defined word!) .

3. MB is the basic notion. MB acts as intentional agent using biological body (BB) as motor instrument and sensory receptor. In the recent case MB imagines and performs active memory recall by selecting the picture and directing its attention to it (still more words to be explained!).

   Dark matter hierarchy as hierarchy of phases of ordinary matter (also photons) assignable to the MB and labelled by the value of effective Planck constant $h_{eff} = n \times h_0$ is a further central element of the general picture. In particular, EEG photons are dark photons with very large value of Planck constant guarantewing that their energies are above thermal threshold. Bio-photons would with energies in visible and UV range would result as dark EEG photons with very large value of h_{eff} transform to ordinary photons.

4. Brain as a hologram is an old idea originally to Karl Pribram. The formation of hologram involves two waves with the same freqeuency: reference wave and the wave representing the target - typically a wave of same frequency reflected from the target. The reference wave is a simple plane wave with some frequency. These waves must interfere so that coherence is required. The interference pattern is stored by the modification of the hologram substrate. The transmission coefficient of the substrate is proportional to $T = |vertU_0 + U_R|^2$, where U_0 and U_R are complex amplitudes.

   If one illuminates the resulting hologram by reference wave U_R the image of the target is formed. If one illuminates the target with the phase conjugate $\overline{U}_R$ of the reference wave - its time reversal $\overline{U}_0$ - the phase conjugate of the image is formed. In ZEO time reversal has precise quantal meaning as also the time reversal of self and of mental image.

   This requires coherence in the length scales of hot and wet brain. Without non-standard large enough value value of h_{eff} makes this is not possible. The coherence for ordinary photons need not be quantum coherence, but is induced by quantum coherence of dark photons transforming to ordinary photons. Quite generally, the coherence of living matter would be induced in this manner from quantum coherence of dark matter at magnetic flux tubes.

7.2.2 TGD inspired model for memory retrieval

With these ingredients one can build a rather simple model for memory retrieval.

1. Memory and sensory mental images is generated as MB creates a reference wave in the formation of hologram as interference pattern of incoming ordinary light beam and dark reference beam. This induces the pattern of neural activity. Coherence is not quantum coherence but inherited from quantum coherence of dark photon beam from MB. Also phase

conjugate in active memory recall comes from MB. The ripples associated with the formation of sensory percept would correspond to the formation of conscious hologram.

2. Phase conjugate wave corresponds to time reversal of wave and would be created in ZEO in BSR reversing the arrow of time for self involved. The phase conjugate of the reference wave generated by MB acting as intentional agent trying to imagine would propagate to geometric past and scatter from the brain substrate acting as a hologram and generate the memory mental image in geometric past at the opposite boundary - the "re-experience", which need not be conscious-to-us. The ripples reported in the first article [J1] would correspond to the scattering of the phase conjugate wave from the hologram.

   This phase conjugate mental image need not be conscious-to-us: the assumption has indeed been that time reversed mental images are not conscious to us. The assumption will be kept also now.

   The next BSR would mean the "death" of the memory mental image and rebirth as a mental image in standard time direction. This would correspond to the "time reflection" generating a signal to the geometric future defining in the recent situation declarative, verbal memory of the mental image. This would be the outcome of imagination experienced by the subject person.

   Why these "normal" mental images are not usually genuine sensory mental images at our level of self hierarchy? A good reason for this is that they would interfere with the ordinary sensory perceptions. We can indeed have this kind of mental images during dreaming and hallucinations. During dreaming it is not a threat for survival as it is during hallucinations. I have discussed a detailed model for imagination as almost sensory mental images [L14] (see `http://tinyurl.com/ydhxen4g`). They would be created by feedback signals from MB via cortex to a level above sensory organs in the hierarchy so that no actual sensory percepts is obtained. Also imagined motor actions would be similar.

   An essential element of the model is that the sensory input is transformed to dark photons beams propagating along flux tubes parallel to axons and being responsible for the communications. The function of nerve pulses would be creation of communication channels by connecting flux tubes associated with axons to longer structures: neural transmitters and various information molecules would do this connecting. Situation would be very much analogous to that in mobile phone communications.

   The notion of re-incarnation is certainly the most controversial aspect of the proposed vision. TGD predicts self hierarchy and sub-selves are identified as mental images so that one can look whether re-incarnation hypothesis makes sense for them. After images appearing periodically would be examples of this kind of mental images: they would be conscious to us and correspond to the level of self hierarchy immediately below us. Since they are typically of different color than the original image, we know that they do not represent a real object. The periods without after image would correspond to the phase conjugates of these mental images and would be un-conscious to us. Essentially a sequence of re-incarnations of mental image would be in question.

3. How can subject person (identifiable as MB!) actively choose the target of the memory recall? In the experiment considered the two pictures were seen by the subject person for a time not longer than $T = 20$ seconds. Both generate a hologram like structure in visual cortex which in good approximation are disjoint patterns of neural activity - presumably regions of coherence induced by quantum coherence of the dark reference beam.

   A conscious choise associated with the memory recall requires that the two areas are labelled by some control parameter which MB can vary. Fixing this parameter directs the attention of MB to either picture. The frequency of the laser beam is the only parameter available. Incoming beam of light corresponds to the energies of visible light and for the ordinary value of Planck constant one cannot vary the frequency. There is however EEG frequency, which can be varied but its ratio to the frequency of visible light is of order 10^{-14} for 10 Hz! The energy $E = hf$ of EEG photons is extremely small and EEG photons should have absolutely no effects on brain or correlate with the contents of consciousness. We however know that it does!

In TGD framework this fact was the original motivation for the hierarchy of Planck constants for which adelic physics [L9, L8] provides a mathematical justification. The choice of the picture to be imagined/attended by MB would mean that the value of h_{eff} associated with it changes. The chosen picture naturally corresponds to a larger value of Planck constant since the maximal conscious information content of the system increases as h_{eff} increase. The increase of h_{eff} requires metabolic energy as directed attention certainly indeed does.

EEG also requires metabolic energy and it would be non-sensical to send information to outer space without any receiver: MB is the natural receiver of this information.

4. A more refined view about memory recall motivated by the second article described above [J8] involves a hierarchical structure in which memory recall is built up so that first the "gist" of the pattern is recalled and then come the details. This is the opposite of what happens in sensory perception in which features are identified first and the holistic view emerges later.

   TGD predicts self hierarchies labelled by the values of h_{eff} and by p-adic length scales. The higher the level of self hierarchy, the longer the corresponding length scale. The "gist" corresponds to large values of h_{eff} and low EEG frequencies whereas details correspond to smaller values of h_{eff} and higher EEG frequencies and smaller wavelengths for ordinary photons. The construction of the memory mental images would correspond to a cascade of state function reductions proceeding from long to short length scales and beginning from largest value of h_{eff} involved. The model for what happens in state function reduction in TGD framework assumes this cascade [K9] [L10] (see `http://tinyurl.com/yyv3v9u8` and `http://tinyurl.com/ycxm2tpd`).

5. It is essential that sensory input is transformed to dark photons at sensory organs propagating to the brain: this also makes the processing of sensory information fast and sensory mental images can be built as standardized mental images - pattern recognition - by forth-and-back signalling between brain and sensory organ combining artificial sensory input from brain with genuine sensory input. It is hard to imagine anything simpler!

6. Neural activity associated with the neural percept preserves the topography of the visual percept so that the shape of the firing pattern in cortex is same as that of object. This cannot be however used as an objection against holography since it is the reading of the neural hologram which generates the image of the object. The topography of the hologram has nothing to do with the shape of the object.

This mechanism should generalize to the case of sensory perception and motor action as its time reversal. MB as an intentional agent would be sending reference beams and their phase conjugates at various frequencies f and values of h_{eff} serving as control knobs! The details are however far from clear. At least to me, it is very difficult to gain detailed understanding. This is to be expected, since our standard intuition of time relies on preferred arrow of time and on the identification of the experienced and geometric time. The following is one particular humble attempt.

1. Are motor action and sensory perception really mirror images as has been assumed hitherto so? The differences between them would be only relative and they would change their roles as the arrow of time is changed?

   Or could it be that the difference is absolute? Motor actions would correspond to BSRs and change the arrow of time. Sensory percepts would correspond to SRSs and preserve the arrow of time. The latter interpretation looks more natural and is consistent with the earlier intuitive but not precise enough view deduced from Libet's findings that sensory percept and motor action correspond to different arrows of time. Let us assume the latter option.

2. Sensory representation, hologram H is formed using reference beam R and object beam O entering to the active boundary of CD. Sensory experience, "reading" of H, is achieved by applying R to H. Subsequent SRSs correspond to R.

   It does not make sense to apply time reversal $\overline{R}$ to H: here the situation differs from that for the ordinary holograms. $\overline{R}$ can be applied only to $\overline{H}$ and would require BSR replacing H with its phase conjugate $\overline{H}$.

If this picture is correct, one would say that the basic activities are printing to make H and reading of H using R. The triplet $\{R, O, H\}$ would be characterize the situation.

The formation of H would be like printing and the application of R to it is like reading of the text. R must correspond to a SRS at the active boundary of CD.

3. Motor representation $\overline{H}$ formed using $\overline{R}$ and conjugate object beam $\overline{O}$ at opposite boundary of CD being now active would be sensory representation in our geometric past having opposite arrow of time. The hypothesis is that what is conscious $\overline{T}$ is unconscious-to-us.

   Our sensory percepts would reflect the motor actions of our temporal mirror image. This motor action has changed the arrow of time for sub-self to that for us and the signals coming from past are passively experienced by us.

4. Our (MB's) motor action - volitional act - involves BSR at some - presumably nearest - level of self hierarchy below us (MB) changing the roles of boundaries of sub-CD in question. At this level the receiver of sensory input is in the geometric past and memory is formed by $\overline{R}$ but as such is not conscious-to-us: this conforms with the findings of the articles. Only the next big state function reduction makes the memory conscious-to-us as sensory or possibly verbal memory and we can read it by making SRSs.

5. The application of $\overline{R}$ to time reversed mental image (conjugate sub-self) $\overline{H}$ would be unconscious memory for us. It would become conscious in BSR for it producing memory at our level: this conforms with the findings of the articles. The application of R to time mental image (sub-self) would be conscious-to-us precognition or sensory experience. Sensory experience are indeed known to be also predictions as is natural in ZEO in which quantum states are superpositions of entire deterministic classical time evolutions.

Needless to add that this view is only a sketch. It is good to list the key assumptions.

1. BSRs correspond to motor actions and SRSs to sensory percepts including precognition.

2. Sub-selves with same time orientation are conscious to use but not their conjugates. I do not have a really good argument for why time reversed mental images should be unconscious-to-us.

3. Only R can be applied to hologram but not $\overline{R}$ as for ordinary holograms.

7.2.3 Could one demonstrate experimentally that the standard view about time is wrong?

The prevailing view in neuroscience and physics identifies experienced time with geometric time despite the fact that these two times have very different properties. In TGD framework these times are not identified but are closely correlated. TGD inspired theory of consciousness based on zero energy ontology (ZEO) [L10, L15] [K2] allows to understand the relationship between the two times and leads to rather dramatic predictions.

TGD interpretation says that in the act of free will MB sends phase conjugate signal to the brain of geometric past or stating it otherwise: replaces the deterministic time evolution of brain (and also its past) with a new one (strictly speaking, replaces their quantum superposition with a new one). This should happen also in the choice of which picture is to be imagined.

Could a modification of the experiment of [J11] replacing imagination with an activity not requiring memory recall allow to demonstrate that the standard view about time is wrong?

1. Consider a thought experiment experiment in which the subject person receives a stimulus and makes a decision to do something - not imagine but something else - during some time interval T after it. Suppose that the decision is found to be preceded by neural activity before the stimulus appears.

   Standard view about time not does allow this since person could have decided about the reaction to the stimulus before it came (precognition would be the only explanation).

   TGD view about the relationship between subjective and geometric time allows this since the decision sends signal to the brain of the past and there is no reason why the moment in past could be before the stimulus.

2. The modification of the above experiment in this manner could mean the reduction of $T = 20$ seconds to - say - $T = 9$ seconds. If the neural activity would appear say $t = 11$ second earlier it would emerge before person has seen the pictures and one would have paradox for standard view about time. However, if the imagined picture relies on memory, this should not happen.

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