Microbes and Altruistic Behavior

In a new paper, researchers Ohad Lewin-Epstein, Ranit Aharonov, and Lilach Hadany at Tel-Aviv University in Israel have theoretically shown that microbes could influence their hosts to act altruistically. [12]

A new study reveals how two populations of neurons in the brain contribute to the brain's inability to correctly assign emotional associations to events. Learning how this information is routed and misrouted could shed light on mental illnesses including depression, addiction, anxiety, and posttraumatic stress disorder. [11]

In dynamic neuronal networks, pervasive oscillatory activity is usually explained by pointing to pacemaking elements that synchronize and drive the network. Recently, however, scientists at The Weizmann Institute of Science in Israel studied synchronized periodic bursting that emerged spontaneously in a network of in vitro rat hippocampus and cortex neurons, finding that roughly 60% of all active neurons were self-sustained oscillators when disconnected from the network – and that each neuron oscillated at its own frequency, which is controlled by the neuron's excitability. [10]

Most biology students will be able to tell you that neural signals are sent via mechanisms such as synaptic transmission, gap junctions, and diffusion processes, but a new study suggests there's another way that our brains transmit information from one place to another. [9]

Physicists are expected to play a vital role in this research, and already have an impressive record of developing new tools for neuroscience. From two-photon microscopy to magneto-encephalography, we can now record activity from individual synapses to entire brains in unprecedented detail. But physicists can do more than simply provide tools for data collection. [8]

Discovery of quantum vibrations in 'microtubules' inside brain neurons supports controversial theory of consciousness.

The human body is a constant flux of thousands of chemical/biological interactions and processes connecting molecules, cells, organs, and fluids, throughout the brain, body, and nervous system. Up until recently it was thought that all these interactions operated in a linear sequence, passing on information much like a runner passing the baton to the next runner. However, the latest findings in quantum biology and biophysics have discovered that there is in fact a tremendous degree of coherence within all living systems.

The accelerating electrons explain not only the Maxwell Equations and the Special Relativity, but the Heisenberg Uncertainty Relation, the Wave-Particle

Duality and the electron's spin also, building the Bridge between the Classical and Quantum Theories.

The Planck Distribution Law of the electromagnetic oscillators explains the electron/proton mass rate and the Weak and Strong Interactions by the diffraction patterns. The Weak Interaction changes the diffraction patterns by moving the electric charge from one side to the other side of the diffraction pattern, which violates the CP and Time reversal symmetry.

The diffraction patterns and the locality of the self-maintaining electromagnetic potential explains also the Quantum Entanglement, giving it as a natural part of the Relativistic Quantum Theory and making possible to understand the Quantum Biology.

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Preface

The human body is a constant flux of thousands of chemical/biological interactions and processes connecting molecules, cells, organs, and fluids, throughout the brain, body, and nervous system. Up until recently it was thought that all these interactions operated in a linear sequence, passing on information much like a runner passing the baton to the next runner. However, the latest findings in quantum biology and biophysics have discovered that there is in fact a tremendous degree of coherence within all living systems. [5]

Quantum entanglement is a physical phenomenon that occurs when pairs or groups of particles are generated or interact in ways such that the quantum state of each particle cannot be described independently – instead, a quantum state may be given for the system as a whole. [4]

I think that we have a simple bridge between the classical and quantum mechanics by understanding the Heisenberg Uncertainty Relations. It makes clear that the particles are not point like but have a dx and dp uncertainty.

Microbes may encourage altruistic behavior

Why do people commonly go out of their way to do something nice for another person, even when it comes at a cost to themselves—and how could such altruistic behavior have evolved? The answer may not just be in our genes, but also in our microbes.

In a new paper, researchers Ohad Lewin-Epstein, Ranit Aharonov, and Lilach Hadany at Tel-Aviv University in Israel have theoretically shown that microbes could influence their hosts to act altruistically. And this influence could be surprisingly effective, with simulations showing that microbes may promote the evolution of altruistic behavior in a population to an even greater extent than genetic factors do.

"I believe the most important aspect of the work is that it changes the way we think about altruism from centering on the animals (or humans) performing the altruistic acts to their microbes," Hadany told Phys.org.

It's already well-known that microbes can affect the behavior of their hosts, with a prime example being how the rabies virus increases aggressive behavior in infected individuals. Research has also shown that the microbiome—the community of microorganisms that inhabit our gut—can even manipulate the hosts' social behavior by infecting neurons and altering neurotransmitter and hormone activity.

Against this backdrop, the researchers in the new study have proposed that microbes may induce a person to help others because the close physical contact (for example, food-sharing, co-sheltering, and grooming) increases the transmission of the microbes from one person to another. So when someone does something nice for us, we are not just the recipient of a kind act, but also of their microbes.

To show that this idea can have a prevailing effect on a population over time, the researchers designed simulations of interacting individuals, some with altruism-inducing microbes, and some without. Then using a prisoner's dilemma payoff scheme, the researchers investigated what happens to this population, its microbes, and its altruistic behavior over many generations.

The results showed that, as long as horizontal transmission (between individuals) of microbes is allowed, altruism-inducing microbes can take over the population, leading to microbe-induced altruism. This result occurs even when only a very small percentage of the population initially carries these altruism-inducing microbes. The simulations also revealed that the evolution of altruism is successful because the microbes have a chance to either meet genetically related microbes in the recipient or infect and transform some of the recipient's microbes into relatives.

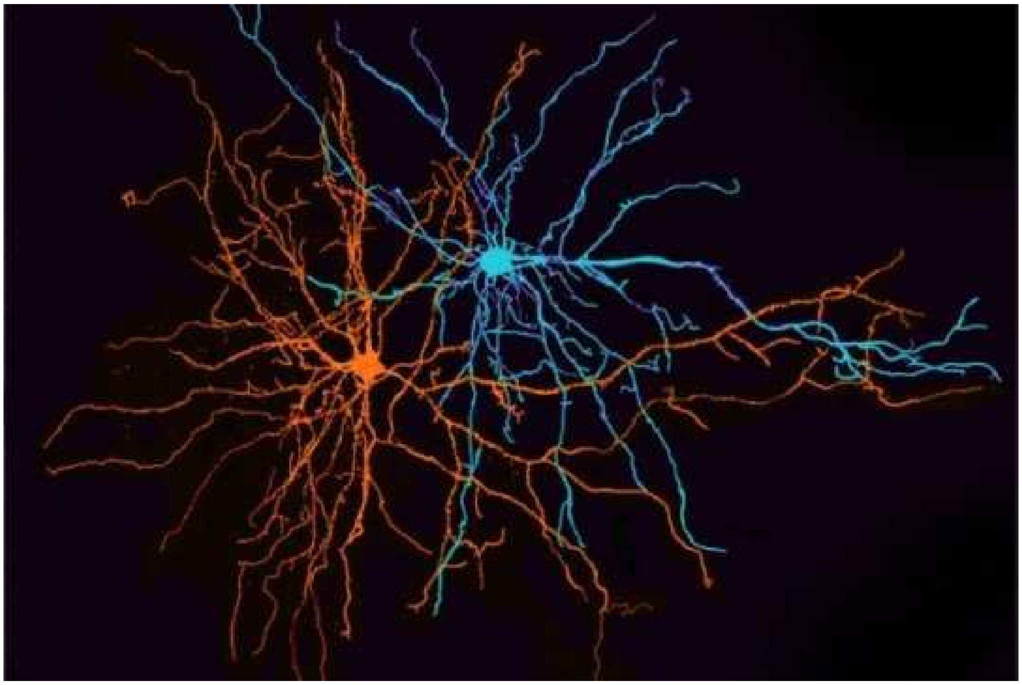
In a variation of this model in which altruism can also be induced by host genes, the researchers found that genetically encoded altruism does not evolve, but microbe-induced altruism continues to evolve whether or not genetic factors are present. Further simulations showed that, although there are some cases in which altruism encoded in genes can persist, microbe-induced altruism persists more often. Overall, the results suggest that microbes may play a dominant and previously overlooked role in the evolution of altruistic behavior.

If microbes do exert such large sway on altruistic behavior, then it raises other intriguing questions, such as whether antibiotics, probiotics, and foods affecting the microbiome may influence the altruistic behavior of their hosts. In the future, the researchers plan to address these possibilities, as well as to test the theory.

"We are now collaborating with experimental biologists in order to empirically validate the predictions of our theory," Hadany said. [12]

How the brain processes emotions

Two neurons of the basolateral amygdala. MIT neuroscientists have found that these neurons play a key role in separating information about positive and negative experiences.



Credit: Anna Beyeler and Praneeth Namburi

Some mental illnesses may stem, in part, from the brain's inability to correctly assign emotional associations to events. For example, people who are depressed often do not feel happy even when experiencing something that they normally enjoy.

A new study from MIT reveals how two populations of neurons in the brain contribute to this process. The researchers found that these neurons, located in an almond-sized region known as the amygdala, form parallel channels that carry information about pleasant or unpleasant events.

Learning more about how this information is routed and misrouted could shed light on mental illnesses including depression, addiction, anxiety, and posttraumatic stress disorder, says Kay Tye, the Whitehead Career Development Assistant Professor of Brain and Cognitive Sciences and a member of MIT's Picower Institute for Learning and Memory.

"I think this project really cuts across specific categorizations of diseases and could be applicable to almost any mental illness," says Tye, the senior author of the study, which appears in the March 31 online issue of Neuron.

The paper's lead authors are postdoc Anna Beyeler and graduate student Praneeth Namburi.

Emotional circuits

In a previous study, Tye's lab identified two populations of neurons involved in processing positive and negative emotions. One of these populations relays information to the nucleus accumbens, which plays a role in learning to seek rewarding experiences, while the other sends input to the centromedial amygdala.

In the new study, the researchers wanted to find out what those neurons actually do as an animal reacts to a frightening or pleasurable stimulus. To do that, they first tagged each population with a light-sensitive protein called channelrhodopsin. In three groups of mice, they labeled cells projecting to the nucleus accumbens, the centromedial amygdala, and a third population that connects to the ventral hippocampus. Tye's lab has previously shown that the connection to the ventral hippocampus is involved in anxiety.

Tagging the neurons is necessary because the populations that project to different targets are otherwise indistinguishable. "As far as we can tell they're heavily intermingled," Tye says. "Unlike some other regions of the brain, there is no topographical separation based on where they go."

After labeling each cell population, the researchers trained the mice to discriminate between two different sounds, one associated with a reward (sugar water) and the other associated with a bitter taste (quinine). They then recorded electrical activity from each group of neurons as the mice encountered the two stimuli. This technique allows scientists to compare the brain's anatomy (which neurons are connected to each other) and its physiology (how those neurons respond to environmental input).

The researchers were surprised to find that neurons within each subpopulation did not all respond the same way. Some responded to one cue and some responded to the other, and some responded to both. Some neurons were excited by the cue while others were inhibited.

"The neurons within each projection are very heterogeneous. They don't all do the same thing," Tye says.

However, despite these differences, the researchers did find overall patterns for each population. Among the neurons that project to the nucleus accumbens, most were excited by the rewarding stimulus and did not respond to the aversive one. Among neurons that project to the central amygdala, most were excited by the aversive cue but not the rewarding cue. Among neurons that project to the ventral hippocampus, the neurons appeared to be more balanced between responding to the positive and negative cues.

"This is consistent with the previous paper, but we added the actual neural dynamics of the firing and the heterogeneity that was masked by the previous approach of optogenetic manipulation," Tye says. "The missing piece of that story was what are these neurons actually doing, in real time, when the animal is being presented with stimuli."

Digging deep

The findings suggest that to fully understand how the brain processes emotions, neuroscientists will have to delve deeper into more specific populations, Tye says.

"Five or 10 years ago, everything was all about specific brain regions. And then in the past four or five years there's been more focus on specific projections. And now, this study presents a window into the next era, when even specific projections are not specific enough. There's still heterogeneity even when you subdivide at this level," she says. "We've still got a long way to go in terms of appreciating the full complexities of the brain."

Another question still remaining is why these different populations are intermingled in the amygdala. One hypothesis is that the cells responding to different inputs need to be able to quickly interact with each other, coordinating responses to an urgent signal, such as an alert that danger is present. "We are exploring the interactions between these different projections, and we think that could be a key to how we so quickly select an appropriate action when we're presented with a stimulus," Tye says.

In the long term, the researchers hope their work will lead to new therapies for mental illnesses. "The first step is to define the circuits and then try to go in animal models of these pathologies and see how these circuits are functioning differently. Then we can try to develop strategies to restore them and try to translate that to human patients," says Beyeler, who is soon starting her own lab at the University of Lausanne to further pursue this line of research. [11]

All for one, one for all: Hippocampal and cortical neurons oscillate both individually and as a network

In dynamic neuronal networks, pervasive oscillatory activity is usually explained by pointing to pacemaking elements that synchronize and drive the network. Recently, however, scientists at The Weizmann Institute of Science in Israel studied synchronized periodic bursting that emerged spontaneously in a network of in vitro rat hippocampus and cortex neurons, finding that roughly 60% of all active neurons were self-sustained oscillators when disconnected from the network – and that each neuron oscillated at its own frequency, which is controlled by the neuron's excitability. The researchers say that neuronal oscillations are widespread in the brain, not only in processes that require timing but also observed over natural activity characteristic of many areas – and that their realization that single neurons operating in default mode with no relevant input tend to oscillate may be important in deciphering the activity in these areas. Similarly, they state, the ability to couple and create large ensembles of synchronized oscillations will be important to understand how the activity spread to larger areas.

Prof. Elisha Moses and Medical Xpress discussed the paper that he and his colleagues published in Proceedings of the National Academy of Sciences.

"Employing multielectrode arrays to follow the spontaneous activity of up to 59 single neurons continuously and simultaneously in a dissociated culture was a basic technical capability that has made our discoveries possible," Moses tells Medical Xpress. "In our labs, we use three basic measurements to monitor network activity in neuronal cultures. The first – the one our paper mainly discusses – is an electrical measurement using multi-electrode arrays, in which the external signature of the neuronal action potential, or spike, is monitored with an array of metal electrodes."

Multielectrode arrays (MEAs) act as neural interfaces that connect neurons to electronic circuitry. The scientists used the MEAs to measure spikes in multiple neurons simultaneously.

"Our second technique was fluorescent calcium imaging, which involves optical imaging of fluorescent cellular activity that changes once the neuron fires and calcium flows inside. An advantage of this technique," Moses explains, "is that a large number of neurons can simultaneously be monitored." Their third method was the classic patch clamp electrophysiology technique, which allows the measurement of single or multiple ion channels in neural and other cell types with great precision, control and detail. "If the cell participates in network activity, there are subtle signs in its activity that can be observed and that inform us of the entire network activation. The use of MEAs in particular," he adds, "has enabled us to measure a regime that was mostly ignored up to now, in which there is no calcium in the external medium. This is a regime that was not probed in detail before, where electrical signals are still measurable but calcium fluorescence imaging is not."

Moses points out that the use of MEAs has turned out to be crucial for observing the oscillations of individual and independently active neurons.

A critical aspect of their study was showing that hippocampal and cortical neurons fire in an oscillatory manner, both individually and as a network. "The periodicity of the network at nonzero calcium concentrations is an observation that has been under some controversy over the years," Moses notes. Previously, the inter-burst interval (the time between bursts, or IBI) has been reported by others to have complicated, even fractal, statistics. If so, Moses points out, this might indicate that neurons are in a critical physical phase transition regime. "However, we showed that the behavior of IBIs depends strongly on the composition of the external fluid in which the measurement is carried out: For a well-controlled composition of this fluid under physiological conditions," he illustrates, "we consistently observed periodic firing behavior; however for fluids with less-controlled components the behavior can indeed become highly complex." Since this was important in resolving the previous reports, the scientists verified and complemented the measurement made with MEAs by using the fluorescence calcium imaging as well as the patch clamp measurement methodologies.

At the same time, Moses adds, the independent periodicity of individual neurons within the neural culture is a completely new observation. "In principle, to get independently firing neurons one must disrupt the synaptic connections that make up the neuronal network. Traditionally, this was done by blocking receptors for a variety of neurotransmitters on the receiving end – that is, at the post-synaptic neuron. This was always followed by a complete suppression of the activity, both of the network (since it was now disconnected) but surprisingly also of the single neurons. Our approach, on the contrary, was to block the sending side, or pre-synaptic neuron."

The researchers achieved this by going to zero calcium concentration in the fluid, which bathes the neuronal network, and relying on MEAs for the measurement of firing activity. At zero calcium the ability of the synapse to release and eventually recruit vesicles for the synaptic connection is disrupted, Moses tells Medical Xpress, thereby being an alternative way to break up the network into individual neurons. "In retrospect, we understand that under physiological conditions – that is, 1-1.5mM calcium and 4-5 mM potassium – the excitability of the neurons is low, and therefore most single neurons are not active when the network is disconnected by blockers. However, when they're connected under the same conditions, network bursts are enabled by the activity of only a few percent of the neurons in the network, whose excitability is higher." (A millimole (mM) is one-thousandth of a mole, the latter being the amount of a chemical substance that contains as many elementary entities – such as atoms, ions, molecules, or free radicals – as there are atoms in 12 grams of carbon-12, which is a constant expressed by Avogadro's number, 6.023 × 1023.)

A key finding was that calcium has an effect on excitability, enabling network connectivity by increasing synaptic release while concurrently reducing single neuron excitability. Moses notes that the important and wide-ranging effects that calcium concentration both in the cell and outside it are well documented. "Calcium is important both for the fast ready to release pool of vesicles and the slower process of recruitment of vesicles to the synapse. By using barium instead of calcium, which is known to play a role in the second process but not in the first, we were able to see synchronization of the frequency but not of the phase, so that we saw network bursts that are wide in time rather than abrupt and simultaneous. We have therefore been able to show that a large number of the properties that make calcium special as a control element come into play in the coupling between neurons in the neuronal culture." At low calcium, he adds, neurons are very active but not coupled; at higher concentration they are less active but highly coupled – so the balance struck by the neural culture is really quite striking, and can be easily disrupted or controlled by varying the concentration of calcium.

Relatedly, magnesium decreased excitability without affecting connectivity, but did not participate in the synaptic processes, where Moses says calcium is the key player. By adding magnesium the researchers were able to dissect the two contributions of calcium, showing what the effect on excitability alone does.

In their paper, the researchers reported that periodic network bursts originate in collective effects rather than in specialized pacemaking elements that control the rest of the network. Specifically, Moses says that there are three scenarios for the origin of periodic firing in the network:

1. One or a few specialized individual neurons oscillate and they drive the network at their own frequency

2. The network has its own dynamics, unaffected by and unrelated to the activity of a single neuron, that fixes its frequency

3. The neurons have individual dynamics with different frequencies, but when connected they influence each other and reach a collective mean frequency that is adopted by the network

"The third scenario has a long and distinguished list of models and of people who've worked on how neurons interact to create this collective effect," Moses says.

"Kuramoto1 suggested the initial model, whereby sinusoidal oscillators interact to make a network oscillation. This was generalized by Strogatz2 to describe units that couple by spikes rather than continuously. Finally, Ermentrout3, Hansel4 and Golomb5 then showed how this is relevant for neurons. However," Moses stresses, "while we have not proven this beyond any doubt, our results strongly support the third scenario by showing the relation between the frequency of the bursting network and the mean of the distribution of the individual neurons. Furthermore, we're able to follow the transition to collective behavior as we gradually crank up the coupling strength between the neurons, and we were able to see how the neurons first synchronize their frequency and then gradually line up their phases so that they are firing simultaneously in the bursting network characteristic of the final stage of synchronization."

The scientists also reported that excitability and connectivity could be modified by systematically varying the network environment. "Network dynamics are usually thought to be determined by their connections – that is, synaptic strength. However, we're able to take the same network and, without any change in its architecture, obtain very different dynamics just by changing the conditions that the synapse is feeling externally." Moses says this shows that most of neuronal dynamics can be controlled externally – for example, by the glial cells or by slightly changing the extracellular ion concentrations – and adds that the external environment can also explain some of the controversies related to the wide variety of neuronal activities that has been observed by different experimental groups over the years.

The paper reports that synaptic blockers elucidated the involvement of neurotransmission in coupling individual neurons. "In general, the role of synaptic blockers for disrupting the network has been confusing because the neural excitability is low," Moses explains. "We were able to raise or lower the excitability by adding potassium or magnesium, respectively, and in both cases saw that the neurons tend to be oscillatory both on their own and collectively when connected. Moreover, the gradual appearance of synchronization as calcium is increased gives a clear intuition onto the role of the connectivity in driving the network oscillations."

In addition, the researchers write that glial cells and other coupling mechanisms should also be considered. "The effect of one neuron on its neighbors is complex, and mediated by several mechanisms," Moses tells Medical Xpress. "A number of mechanisms that influence the coupling between neurons exist, such as the effect of glial cells, which are abundant in our neuronal culture and whose influence on the network activity is generally accepted to be relevant and important. Our work has not covered the possible contribution of glial cells, and this is certainly an open problem that can be of interest in our future studies."

Medical Xpress asked Moses if, given the paper's focus on the hippocampus, he has any comments on the work by Berger6 and his colleagues at the University of Southern California in Los Angeles in implementing a functional hippocampal prosthesis – a device that has performed well in laboratory testing in animals and reportedly is being evaluated for use in human patients. "There's no doubt in my mind that prosthetics will prove a driving force in unraveling fundamental questions of neuroscience, since they are driven by a real medical need and can provide a unique window into the function of the brain along with a handle into influencing its dynamics in ways that we have not seen before. Since the prosthetics offer a communication gate into neurons in the brain, our results offer insight and can be important in identifying how to talk with those neurons in vivo. The unknown language or code by which neurons communicate is a major question that is still not well understood, and our realization that oscillations are the basic building block of the neuronal repertoire may turn out useful in this context."

Regarding the researchers' plans, Moses says, two immediate questions relate to the nature of the individual neuronal oscillations and of the networks bursts. "We intend to identify different cells within the culture, and to find out the range of oscillatory behavior and frequencies for the different types. Current ability to separate neural populations by FACS promises the ability to build networks of different neuronal elements and to relate neuronal properties with their firing dynamics. In the longer term, our lab has an ongoing effort into the construction of neuronal logical devices, where the addition of a natural intrinsic clock for the computation is of fundamental importance. In parallel, we cooperate with theoretical physicists from Diderot University in Paris who are developing predictive models to describe the transition to synchrony." In addition, the group is looking into the ability to externally excite neurons with technologies such as magnetic and ultrasonic stimulation, and other avenues of research involve the network structure of activity in the whole brain.

"Synchrony covers a wide range of phenomena, from the synchronization of firefly nocturnal firing to the discovery of menstrual synchrony by McClintock7 and its implications on how humans communicate," Moses tells Medical Xpress. "Our results add neural synchrony as an important member to this family of systems where coupling between individual oscillating units leads to a large collective bursting oscillations." In general, he adds, the dynamics of neural networks are interesting not because they model the brain (they actually don't, since the connections are very different), but rather because they present a simplified system in which neuronal activity can be understood in full, presenting a model to study the interactions between the single neurons and the collective computation that results.

"Our work is mostly a successful application of synergy between physics and neuroscience," Moses concludes. "We've been able to join the physical picture of a network and the coupling between its nodes, with the neurobiological picture of single neuron excitability and dynamics." [10]

Scientists discover that our brain waves can be sent by electrical fields

Researchers in the US have recorded neural spikes travelling too slowly in the brain to be explained by conventional signaling mechanisms. In the absence of other plausible explanations, the scientists believe these brain waves are being transmitted by a weak electrical field, and they've been able to detect one of these in mice.

"Researchers have thought that the brain's endogenous electrical fields are too weak to propagate wave transmission," said Dominique Durand, a biomedical engineer at Case Western Reserve University. "But it appears the brain may be using the fields to communicate without synaptic transmissions, gap junctions or diffusion."

Running computer simulations to model their hypothesis, the researchers found that electrical fields can mediate propagation across layers of neurons. While the field is of low amplitude (approximately 2–6 mV/mm), it's able to excite and activate immediate neighbours, which subsequently activate more neurons, travelling across the brain at about 10 centimeters per second.

Testing on mouse hippocampi (the central part of the brain associated with memory and spatial navigation) produced similar results, and when the researchers applied a blocking field, it slowed down the speed of the wave.

According to the researchers, this is evidence that the propagation mechanism for the activity is consistent with the electrical field.

"The results indicate that electric fields (ephaptic effects) are capable of mediating propagation of self-regenerating neural waves," they write. "This novel mechanism coupling cell-by-volume conduction could be involved in other types of propagating neural signals, such as slow-wave sleep, sharp hippocampal waves, theta waves, or seizures."

If their findings, which are reported in The Journal of Neuroscience, can be expounded in further studies, it could help us to better understand how brain waves are associated with things like memory, epilepsy, and healthy physiology.

"Others have been working on such phenomena for decades, but no one has ever made these connections," said Steven J. Schiff, director of the Centre for Neural Engineering at Penn State University, who wasn't involved in the research.

"The implications are that such directed fields can be used to modulate both pathological activities, such as seizures, and to interact with cognitive rhythms that help regulate a variety of processes in the brain." [9]

Can There Be a Physics of the Brain?

The recently launched brain initiatives have thrown financial support behind one of the greatest intellectual challenges of our time: to develop an understanding of “how the brain works.” Physicists are expected to play a vital role in this research, and already have an impressive record of developing new tools for neuroscience. From two-photon microscopy to magneto-encephalography, we can now record activity from individual synapses to entire brains in unprecedented detail. But physicists can do more than simply provide tools for data collection.

One of the great successes of physics is universality—the idea that at larger scales, some small-scale details can be ignored. For neuroscience, this is where physics could have its biggest impact, providing general principles of brain function. Ideally, these principles should come in the form of equations. However, there is skepticism from both sides (biology and physics) that this could really be achieved. The brain is a highly complex structure with tens of distinct neurotransmitters and receptors, a menagerie of cell types, and precise wiring patterns]. Can these small-scale details really be ignored? The answer looks like it might be yes, with glimmers of universality beginning to appear in neuroscience.

Sethna and colleagues argue that systems biology models are governed by only a few “stiff” parameters. The values of all the other “sloppy” parameters vary without strongly influencing the state of the system. Recent experiments on networks of cultured neurons support this view, while computational models of the simple nervous systems of crabs and worms show that many different combinations of parameters can be used to produce essentially the same circuit function. Biological experiments show that while the values of many parameters constantly change, neural functions remain remarkably stable. In all these cases, diverse arrangements of microscopic variables produce the same macroscopic invariant.

Universality is also central to the hypothesis that the cerebral cortex is poised near a critical point, where only one variable, a control parameter, would govern the macroscopic phase of the system. Near the critical point, correlations between neurons would occur across all scales, leading to optimized communication. In addition, susceptibility would be greatest there, making the cortex most responsive to external stimuli. Experimental evidence for this hypothesis has accumulated over the last ten years: power laws and scaling relationships have been found in neuronal cultures, and in the cortices of monkeys and humans. Despite the evidence and the appeal of this idea, there are some doubts.

The current deluge of neural data has opened up many pathways to explore, and there is a healthy debate about competing ideas. Many years from now, as physicists seek to contribute to neuroscience, it is likely their biggest challenges will no longer be in developing new tools for collecting data. Rather, they will be in determining how large numbers of neurons collectively interact to produce emergent properties like cognition and consciousness. This will be a frontier for interesting new physics, unlike anything we have seen before. [8]

Quantum Consciousness

A review and update of a controversial 20-year-old theory of consciousness published in Physics of Life Reviews claims that consciousness derives from deeper level, finer scale activities inside brain neurons. The recent discovery of quantum vibrations in "microtubules" inside brain neurons corroborates this theory, according to review authors Stuart Hameroff and Sir Roger Penrose. They suggest that EEG rhythms (brain waves) also derive from deeper level microtubule vibrations, and that from a practical standpoint, treating brain microtubule vibrations could benefit a host of mental, neurological, and cognitive conditions. [6]

Extensive scientific investigation has found that a form of quantum coherence operates within living biological systems through what is known as biological excitations and biophoton emission. What this means is that metabolic energy is stored as a form of electromechanical and electromagnetic excitations. These coherent excitations are considered responsible for generating and maintaining long-range order via the transformation of energy and very weak electromagnetic signals. After nearly twenty years of experimental research, Fritz-Albert Popp put forward the hypothesis that biophotons are emitted from a coherent electrodynamics field within the living system.

What this means is that each living cell is giving off, or resonating, a biophoton field of coherent energy. If each cell is emitting this field, then the whole living system is, in effect, a resonating field-a ubiquitous nonlocal field. And since biophotons are the entities through which the living system communicates, there is near-instantaneous intercommunication throughout. And this, claims Popp, is the basis for coherent biological organization -- referred to as quantum coherence. This discovery led Popp to state that the capacity for evolution rests not on aggressive struggle and rivalry but on the capacity for communication and cooperation. In this sense the built-in capacity for species evolution is not based on the individual but rather living systems that are interlinked within a coherent whole: Living systems are thus neither the subjects alone, nor objects isolated, but both subjects and objects in a mutually communicating universe of meaning. . . . Just as the cells in an organism take on different tasks for the whole, different populations enfold information not only for themselves, but for all other organisms, expanding the consciousness of the whole, while at the same time becoming more and more aware of this collective consciousness.

Biophysicist Mae-Wan Ho describes how the living organism, including the human body, is coordinated throughout and is "coherent beyond our wildest dreams." It appears that every part of our body is "in communication with every other part through a dynamic, tunable, responsive, liquid crystalline medium that pervades the whole body, from organs and tissues to the interior of every cell."

What this tells us is that the medium of our bodies is a form of liquid crystal, an ideal transmitter of communication, resonance, and coherence. These relatively new developments in biophysics have discovered that all biological organisms are constituted of a liquid crystalline medium. Further, DNA is a liquid-crystal, lattice-type structure (which some refer to as a liquid crystal gel), whereby body cells are involved in a holographic instantaneous communication via the emitting of biophotons (a source based on light). This implies that all living biological organisms continuously emit radiations of light that form a field of coherence and communication. Moreover, biophysics has discovered that living organisms are permeated by quantum wave forms. [5]

Consciousness as a State of Matter

We examine the hypothesis that consciousness can be understood as a state of matter, "perceptronium", with distinctive information processing abilities. We explore five basic principles that may distinguish conscious matter from other physical systems such as solids, liquids and gases: the information, integration, independence, dynamics and utility principles. If such principles can identify conscious entities, then they can help solve the quantum factorization problem: why do conscious observers like us perceive the particular Hilbert space factorization corresponding to classical space (rather than Fourier space, say), and more generally, why do we perceive the world around us as a dynamic hierarchy of objects that are strongly integrated and relatively independent? Tensor factorization of matrices is found to play a central role, and our technical results include a theorem about Hamiltonian separability (defined using Hilbert-Schmidt superoperators) being maximized in the energy eigenbasis. Our approach generalizes Giulio Tononi's integrated information framework for neural-network-based consciousness to arbitrary quantum systems, and we find interesting links to error-correcting codes, condensed matter criticality, and the Quantum Darwinism program, as well as an interesting connection between the emergence of consciousness and the emergence of time. [7]

Quantum Entanglement

Measurements of physical properties such as position, momentum, spin, polarization, etc. performed on entangled particles are found to be appropriately correlated. For example, if a pair of particles is generated in such a way that their total spin is known to be zero, and one particle is found to have clockwise spin on a certain axis, then the spin of the other particle, measured on the same axis, will be found to be counterclockwise. Because of the nature of quantum measurement, however, this behavior gives rise to effects that can appear paradoxical: any measurement of a property of a particle can be seen as acting on that particle (e.g. by collapsing a number of superimposed states); and in the case of entangled particles, such action must be on the entangled system as a whole. It thus appears that one particle of an entangled pair "knows" what measurement has been performed on the other, and with what outcome, even though there is no known means for such information to be communicated between the particles, which at the time of measurement may be separated by arbitrarily large distances. [4]

The Bridge

The accelerating electrons explain not only the Maxwell Equations and the Special Relativity, but the Heisenberg Uncertainty Relation, the wave particle duality and the electron's spin also, building the bridge between the Classical and Quantum Theories. [1]

Accelerating charges

The moving charges are self maintain the electromagnetic field locally, causing their movement and this is the result of their acceleration under the force of this field. In the classical physics the charges will distributed along the electric current so that the electric potential lowering along the current, by linearly increasing the way they take every next time period because this accelerated motion.
The same thing happens on the atomic scale giving a dp impulse difference and a dx way difference between the different part of the not point like particles.

Relativistic effect

Another bridge between the classical and quantum mechanics in the realm of relativity is that the charge distribution is lowering in the reference frame of the accelerating charges linearly: ds/dt = at (time coordinate), but in the reference frame of the current it is parabolic: $s = a/2\ t^2$ (geometric coordinate).

Heisenberg Uncertainty Relation

In the atomic scale the Heisenberg uncertainty relation gives the same result, since the moving electron in the atom accelerating in the electric field of the proton, causing a charge distribution on delta x position difference and with a delta p momentum difference such a way that they product is about the half Planck reduced constant. For the proton this delta x much less in the nucleon, than in the orbit of the electron in the atom, the delta p is much higher because of the greater proton mass.

This means that the electron and proton are not point like particles, but has a real charge distribution.

Wave – Particle Duality

The accelerating electrons explains the wave – particle duality of the electrons and photons, since the elementary charges are distributed on delta x position with delta p impulse and creating a wave packet of the electron. The photon gives the electromagnetic particle of the mediating force of the electrons electromagnetic field with the same distribution of wavelengths.

Atomic model

The constantly accelerating electron in the Hydrogen atom is moving on the equipotential line of the proton and it's kinetic and potential energy will be constant. Its energy will change only when it is changing its way to another equipotential line with another value of potential energy or getting free with enough kinetic energy. This means that the Rutherford-Bohr atomic model is right and only that changing acceleration of the electric charge causes radiation, not the steady acceleration. The steady acceleration of the charges only creates a centric parabolic steady electric field around the charge, the magnetic field. This gives the magnetic moment of the atoms, summing up the proton and electron magnetic moments caused by their circular motions and spins.

The Relativistic Bridge

Commonly accepted idea that the relativistic effect on the particle physics it is the fermions' spin - another unresolved problem in the classical concepts. If the electric charges can move only with accelerated motions in the self maintaining electromagnetic field, once upon a time they would reach the velocity of the electromagnetic field. The resolution of this problem is the spinning particle, constantly accelerating and not reaching the velocity of light because the acceleration is radial. One origin of the Quantum Physics is the Planck Distribution Law of the electromagnetic oscillators, giving equal intensity for 2 different wavelengths on any temperature. Any of these two wavelengths will give equal intensity diffraction patterns, building different asymmetric constructions, for example proton - electron structures (atoms), molecules, etc. Since the particles are centers of diffraction patterns they also have particle – wave duality as the electromagnetic waves have. [2]

The weak interaction

The weak interaction transforms an electric charge in the diffraction pattern from one side to the other side, causing an electric dipole momentum change, which violates the CP and time reversal symmetry. The Electroweak Interaction shows that the Weak Interaction is basically electromagnetic in nature. The arrow of time shows the entropy grows by changing the temperature dependent diffraction patterns of the electromagnetic oscillators.

Another important issue of the quark model is when one quark changes its flavor such that a linear oscillation transforms into plane oscillation or vice versa, changing the charge value with 1 or -1. This kind of change in the oscillation mode requires not only parity change, but also charge and time changes (CPT symmetry) resulting a right handed anti-neutrino or a left handed neutrino.

The right handed anti-neutrino and the left handed neutrino exist only because changing back the quark flavor could happen only in reverse, because they are different geometrical constructions, the u is 2 dimensional and positively charged and the d is 1 dimensional and negatively charged. It needs also a time reversal, because anti particle (anti neutrino) is involved.

The neutrino is a 1/2spin creator particle to make equal the spins of the weak interaction, for example neutron decay to 2 fermions, every particle is fermions with ½ spin. The weak interaction changes the entropy since more or less particles will give more or less freedom of movement. The entropy change is a result of temperature change and breaks the equality of oscillator diffraction intensity of the Maxwell–Boltzmann statistics. This way it changes the time coordinate measure and makes possible a different time dilation as of the special relativity.

The limit of the velocity of particles as the speed of light appropriate only for electrical charged particles, since the accelerated charges are self maintaining locally the accelerating electric force. The neutrinos are CP symmetry breaking particles compensated by time in the CPT symmetry, that is the time coordinate not works as in the electromagnetic interactions, consequently the speed of neutrinos is not limited by the speed of light.

The weak interaction T-asymmetry is in conjunction with the T-asymmetry of the second law of thermodynamics, meaning that locally lowering entropy (on extremely high temperature) causes the weak interaction, for example the Hydrogen fusion.

Probably because it is a spin creating movement changing linear oscillation to 2 dimensional oscillation by changing d to u quark and creating anti neutrino going back in time relative to the proton and electron created from the neutron, it seems that the anti neutrino fastest then the velocity of the photons created also in this weak interaction?

A quark flavor changing shows that it is a reflection changes movement and the CP- and T- symmetry breaking!!! This flavor changing oscillation could prove that it could be also on higher level such as atoms, molecules, probably big biological significant molecules and responsible on the aging of the life.

Important to mention that the weak interaction is always contains particles and antiparticles, where the neutrinos (antineutrinos) present the opposite side. It means by Feynman's interpretation that these particles present the backward time and probably because this they seem to move faster than the speed of light in the reference frame of the other side.

Finally since the weak interaction is an electric dipole change with ½ spin creating; it is limited by the velocity of the electromagnetic wave, so the neutrino's velocity cannot exceed the velocity of light.

The General Weak Interaction

The Weak Interactions T-asymmetry is in conjunction with the T-asymmetry of the Second Law of Thermodynamics, meaning that locally lowering entropy (on extremely high temperature) causes for example the Hydrogen fusion. The arrow of time by the Second Law of Thermodynamics shows the increasing entropy and decreasing information by the Weak Interaction, changing the temperature dependent diffraction patterns. A good example of this is the neutron decay, creating more particles with less known information about them.

The neutrino oscillation of the Weak Interaction shows that it is a general electric dipole change and it is possible to any other temperature dependent entropy and information changing diffraction pattern of atoms, molecules and even complicated biological living structures.

We can generalize the weak interaction on all of the decaying matter constructions, even on the biological too. This gives the limited lifetime for the biological constructions also by the arrow of time. There should be a new research space of the Quantum Information Science the 'general neutrino oscillation' for the greater then subatomic matter structures as an electric dipole change.

There is also connection between statistical physics and evolutionary biology, since the arrow of time is working in the biological evolution also.
The Fluctuation Theorem says that there is a probability that entropy will flow in a direction opposite to that dictated by the Second Law of Thermodynamics. In this case the Information is growing that is the matter formulas are emerging from the chaos. So the Weak Interaction has two directions, samples for one direction is the Neutron decay, and Hydrogen fusion is the opposite direction.

Fermions and Bosons

The fermions are the diffraction patterns of the bosons such a way that they are both sides of the same thing.

Van Der Waals force

Named after the Dutch scientist Johannes Diderik van der Waals – who first proposed it in 1873 to explain the behaviour of gases – it is a very weak force that only becomes relevant when atoms and molecules are very close together. Fluctuations in the electronic cloud of an atom mean that it will have an instantaneous dipole moment. This can induce a dipole moment in a nearby atom, the result being an attractive dipole–dipole interaction.

Electromagnetic inertia and mass

Electromagnetic Induction

Since the magnetic induction creates a negative electric field as a result of the changing acceleration, it works as an electromagnetic inertia, causing an electromagnetic mass. [1]

Relativistic change of mass

The increasing mass of the electric charges the result of the increasing inductive electric force acting against the accelerating force. The decreasing mass of the decreasing acceleration is the result of the inductive electric force acting against the decreasing force. This is the relativistic mass change explanation, especially importantly explaining the mass reduction in case of velocity decrease.

The frequency dependence of mass

Since $E = hv$ and $E = mc^2$, $m = hv /c^2$ that is the m depends only on the v frequency. It means that the mass of the proton and electron are electromagnetic and the result of the electromagnetic induction, caused by the changing acceleration of the spinning and moving charge! It could be that the m_o inertial mass is the result of the spin, since this is the only accelerating motion of the electric charge. Since the accelerating motion has different frequency for the electron in the atom and the proton, they masses are different, also as the wavelengths on both sides of the diffraction pattern, giving equal intensity of radiation.

Electron – Proton mass rate

The Planck distribution law explains the different frequencies of the proton and electron, giving equal intensity to different lambda wavelengths! Also since the particles are diffraction patterns they have some closeness to each other – can be seen as a gravitational force. [2]

There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a high probability event. The asymmetric sides are creating different frequencies of electromagnetic radiations being in the same intensity level and compensating each other. One of these compensating ratios is the electron – proton mass ratio. The lower energy side has no compensating intensity level, it is the dark energy and the corresponding matter is the dark matter.

Gravity from the point of view of quantum physics

The Gravitational force

The gravitational attractive force is basically a magnetic force.

The same electric charges can attract one another by the magnetic force if they are moving parallel in the same direction. Since the electrically neutral matter is composed of negative and positive charges they need 2 photons to mediate this attractive force, one per charges. The Bing Bang caused parallel moving of the matter gives this magnetic force, experienced as gravitational force.

Since graviton is a tensor field, it has spin = 2, could be 2 photons with spin = 1 together.

You can think about photons as virtual electron – positron pairs, obtaining the necessary virtual mass for gravity.

The mass as seen before a result of the diffraction, for example the proton – electron mass rate Mp=1840 Me. In order to move one of these diffraction maximum (electron or proton) we need to intervene into the diffraction pattern with a force appropriate to the intensity of this diffraction maximum, means its intensity or mass.

The Big Bang caused acceleration created radial currents of the matter, and since the matter is composed of negative and positive charges, these currents are creating magnetic field and attracting forces between the parallel moving electric currents. This is the gravitational force experienced by the matter, and also the mass is result of the electromagnetic forces between the charged particles. The positive and negative charged currents attracts each other or by the magnetic forces or by the much stronger electrostatic forces!?

The gravitational force attracting the matter, causing concentration of the matter in a small space and leaving much space with low matter concentration: dark matter and energy.

There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a high probability event. The asymmetric sides are creating different frequencies of electromagnetic radiations being in the same intensity level and compensating each other. One of these compensating ratios is the electron – proton mass ratio. The lower energy side has no compensating intensity level, it is the dark energy and the corresponding matter is the dark matter.

The Higgs boson

By March 2013, the particle had been proven to behave, interact and decay in many of the expected ways predicted by the Standard Model, and was also tentatively confirmed to have + parity and zero spin, two fundamental criteria of a Higgs boson, making it also the first known scalar particle to be discovered in nature, although a number of other properties were not fully proven and some partial results do not yet precisely match those expected; in some cases data is also still awaited or being analyzed.

Since the Higgs boson is necessary to the W and Z bosons, the dipole change of the Weak interaction and the change in the magnetic effect caused gravitation must be conducted. The Wien law is also important to explain the Weak interaction, since it describes the T_{max} change and the diffraction patterns change. [2]

Higgs mechanism and Quantum Gravity

The magnetic induction creates a negative electric field, causing an electromagnetic inertia. Probably it is the mysterious Higgs field giving mass to the charged particles? We can think about the photon as an electron-positron pair, they have mass. The neutral particles are built from negative and positive charges, for example the neutron, decaying to proton and electron. The wave – particle duality makes sure that the particles are oscillating and creating magnetic induction as an inertial mass, explaining also the relativistic mass change. Higher frequency creates stronger magnetic induction, smaller frequency results lesser magnetic induction. It seems to me that the magnetic induction is the secret of the Higgs field.

In particle physics, the Higgs mechanism is a kind of mass generation mechanism, a process that gives mass to elementary particles. According to this theory, particles gain mass by interacting with the Higgs field that permeates all space. More precisely, the Higgs mechanism endows gauge bosons in a gauge theory with mass through absorption of Nambu–Goldstone bosons arising in spontaneous symmetry breaking.

The simplest implementation of the mechanism adds an extra Higgs field to the gauge theory. The spontaneous symmetry breaking of the underlying local symmetry triggers conversion of components of this Higgs field to Goldstone bosons which interact with (at least some of) the other fields in the theory, so as to produce mass terms for (at least some of) the gauge bosons. This mechanism may also leave behind elementary scalar (spin-0) particles, known as Higgs bosons.

In the Standard Model, the phrase "Higgs mechanism" refers specifically to the generation of masses for the $W^{\pm}$, and Z weak gauge bosons through electroweak symmetry breaking. The Large Hadron Collider at CERN announced results consistent with the Higgs particle on July 4, 2012 but stressed that further testing is needed to confirm the Standard Model.

What is the Spin?

So we know already that the new particle has spin zero or spin two and we could tell which one if we could detect the polarizations of the photons produced. Unfortunately this is difficult and neither ATLAS nor CMS are able to measure polarizations. The only direct and sure way to confirm that the particle is indeed a scalar is to plot the angular distribution of the photons in the rest frame of the centre of mass. A spin zero particles like the Higgs carries no directional information away from the original collision so the distribution will be even in all directions. This test will be possible when a much larger number of events have been observed. In the mean time we can settle for less certain indirect indicators.

The Graviton

In physics, the graviton is a hypothetical elementary particle that mediates the force of gravitation in the framework of quantum field theory. If it exists, the graviton is expected to be massless (because the gravitational force appears to have unlimited range) and must be a spin-2 boson. The spin follows from the fact that the source of gravitation is the stress-energy tensor, a second-rank tensor (compared to electromagnetism's spin-1 photon, the source of which is the four-current, a first-rank tensor). Additionally, it can be shown that any massless spin-2 field would give rise to a force indistinguishable from gravitation, because a massless spin-2 field must couple to (interact with) the stress-energy tensor in the same way that the gravitational field does. This result suggests that, if a massless spin-2 particle is discovered, it must be the graviton, so that the only experimental verification needed for the graviton may simply be the discovery of a massless spin-2 particle. [3]

Conclusions

The current deluge of neural data has opened up many pathways to explore, and there is a healthy debate about competing ideas. Many years from now, as physicists seek to contribute to neuroscience, it is likely their biggest challenges will no longer be in developing new tools for collecting data. Rather, they will be in determining how large numbers of neurons collectively interact to produce emergent properties like cognition and consciousness. This will be a frontier for interesting new physics, unlike anything we have seen before. [8]

Discovery of quantum vibrations in 'microtubules' inside brain neurons supports controversial theory of consciousness. [6]

These relatively new developments in biophysics have discovered that all biological organisms are constituted of a liquid crystalline medium. Further, DNA is a liquid-crystal, lattice-type structure (which some refer to as a liquid crystal gel), whereby body cells are involved in a holographic instantaneous communication via the emitting of biophotons (a source based on light). This implies that all living biological organisms continuously emit radiations of light that form a field of coherence and communication. Moreover, biophysics has discovered that living organisms are permeated by quantum wave forms. [5]

One of the most important conclusions is that the electric charges are moving in an accelerated way and even if their velocity is constant, they have an intrinsic acceleration anyway, the so called spin, since they need at least an intrinsic acceleration to make possible they movement .

The accelerated charges self-maintaining potential shows the locality of the relativity, working on the quantum level also. [1]

The bridge between the classical and quantum theory is based on this intrinsic acceleration of the spin, explaining also the Heisenberg Uncertainty Principle. The particle – wave duality of the electric charges and the photon makes certain that they are both sides of the same thing.

The Secret of Quantum Entanglement that the particles are diffraction patterns of the electromagnetic waves and this way their quantum states every time is the result of the quantum state of the intermediate electromagnetic waves. [2]

Basing the gravitational force on the accelerating Universe caused magnetic force and the Planck Distribution Law of the electromagnetic waves caused diffraction gives us the basis to build a Unified Theory of the physical interactions also.

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