Mars Can Wait: Facing the Challenges of Our Civilization

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ABSTRACT: We are overwhelmed by warnings about inevitable geophysical and human problems. Earth is beset by escalating, man-made, environmental crises and our exploding population will eventually lack water, food and vital materials. This suggests, together with increasing poverty, deepening social unrest and advanced techniques for mass killing, that civilization will break down long before atmospheric CO_2 or resistant microbes become catastrophic. Despite intensive searching, life has not been found in space, even though thousands of planets have been found and life there may be as problematic and unpredictable as on Earth. The human brain is already a 'universe', with 85 billion neurons and a hundred trillion synapses, more than the stars in our galaxy. Understanding consciousness, the brain, its aging and pathologies, and eliminating the propensity for human aggression are urgent challenges. During 1958–2012, NASA spent $800 billion. In contrast, the annual cost of brain disease in the U.S. is $600 billion, more than cardiovascular disease and cancer combined. We suggest that a massive switching of financial and human resources is required to explore the full potential of the human brain. Visiting Mars can wait. We further propose a novel Two-Brain Hypothesis: the animal 'brain' evolved as two fundamentally different though interdependent, complementary organs: one electroionic (tangible, known and accessible), and the other, electromagnetic (intangible and difficult to access) – a relatively independent, stable, structured and functional 3D compendium of variously induced interacting EM fields.

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The clinician's marathon runs between life and death, with little time to consider the validity of existential threats that threaten human civilization. We are warned of a nuclear holocaust and the potential of Ebola, MERSA and SARS, threatened with a gathering global population explosion that cannot be fed and an aging population (both stimulated by modern medicine), and promised eventual excess of carbon dioxide, rising temperatures, melting ice, flooded land and water wars. The most serious problem, however, is human aggression.

Clinicians struggling with a premature newborn, a mangled victim of drunk-driving or irreversible vegetative states perhaps subconsciously wonder whether time, energy and money could be better spent. We submit: if civilization is to survive, preference in allocation of finance and human resources must be directed to better exploitation of the nature, workings and potential of the 'brain' by which *Homo sapiens* rose and may yet fall.

LIFE OUT THERE: PROBLEMATIC AND UNPREDICTABLE

Thousands of planets have been found. Does extraterritorial life exist, less or more like ours? Do spatial conditions that suit humans exist? Evidence suggests that life came from space (Panspermia). Did extraterrestrial, natural selection of a nucleotide-based reproductive process start in space, based perhaps on fullerene, a hollow aromatic molecule of 60 Carbon atoms? [1]. Decades of costly search by the SETI Institute have not found intelligent life, whether in civilizations like ours, or with eyes less kind than E.T's. Theories on the Universe abound: one or many, copies of 'me' or 'us' in each; perhaps an arrow of time opposite to ours. Is there Nothing; is it all in our minds? Critically, spatial expansion is so fast we cannot know the 'beyond': 'looped', 'stringed', many dimensioned, an infinitely studied *ad infinitum*? Hamlet pondered suicide, to "shuffle off our mortal coil." Not knowing what was beyond, undecided he perished anyway [2]. Man must choose in time if civilization is not to perish. The choice sits on our shoulders.

THE HUMAN UNIVERSE

Man's brain: 85 billion neurons and a hundred trillion connections between them; more synapses than stars in our galaxy; a product of gravitation, quantum mechanics and evolution by survival. For a few generations, it is crucial that increased knowledge and understanding of brain anatomy and function, the mind and consciousness, have absolute priority if we are to find ways to ameliorate extremes of human aggression, mental sickness, and brain aging and pathologies. These are challenges enough for health care practitioners and researchers; they also challenge the hubris of society. This will demand a rapid and massive reallocation of material and human resources and fundamental rethinking on research directions.

Between 1958 and 2012, NASA spent $16 billion annually ($800 billion in total), four times that spent on health research [3]. The overall annual economic cost of brain maladies in the USA is $600 billion. Federal funding for advanced brain research is just $200 million annually [4]. European brain research expenditure is a fraction of that. Claims of immediate, economic and human side benefits from space research, for jobs, inventions and curiosity, apply no less to the life sciences. Cosmic issues fade before urgent exploration of the human brain. Mars can surely wait 30–50 years. Potential nuclear wars, genocide, human aggression; the prevention and treatment of epilepsy, multiple sclerosis, Alzheimer's, dementia, Parkinson's and autism spectrum; as well as an aging population, must put humanity and an endangered civilization first. For this, maximizing the application of modern physical theory for stepped-up brain research is a critical issue.

MODERN PHYSICAL THEORY: UNPREDICTABLE, WEIRD, PROMISING

Some consequences of quantum mechanics, such as the wave-mechanical equation, which enables intuitive understanding of atomic molecular bonding as a 3D overlapping of smeared-out charge density, are common tools of medicine. Moreover, modern clinical practice and research have long enjoyed fruits of the new physics; these include electron microscopy, X-ray crystallography, spectroscopy, imaging by positron emission tomography (PET), functional magnetic resonance (fMRI) and electroencephalography [5]. Yet our understanding of phenomena such as action potentials and their conduction along axons is still based on classical electrochemistry, while potential but often problematic unifying concepts, e.g., consciousness, flounder endlessly.

We assume that widely distributed detectors in the awake brain constantly sense different features such as size, color, tone, shape, sound and motion, and bind them together with associated thoughts and memories into a stream of conscious experiences uniquely personal [6], a key element in the central control of human behavior and outlook. One of the many theories on this controversial concept [7] claims that quantum mechanical interaction with gravity in microtubules of neurons influences brain activity as a whole [8] – also controversial [9]. Electromagnetic (EM) fields have also been thought to be involved in consciousness. As a result of membrane electrical activity of large groups of brain neurons firing synchronously, the fields are considered strong enough to feed back to their neuron sources [7]. The synchronization strongly correlates with attention, awareness and conscious perception, precipitating the controversial view that oscillation frequencies in the firing neurons perturb a global EM field external to the neurons in a pattern representing neuronal information from different sources in the brain.

NATURAL SELECTION OF EM INDUCTION IN THE NERVOUS SYSTEM

Nature has long exploited electrostatics to protect animals with electric darts. However, a varying flow of charge, whatever its form, is accompanied by a magnetic field. Apart from the use of magnetism in navigation by some animals, magnetic fields have usually been regarded as mere by-products of electroionic nervous activity. This is perhaps because of difficulty in measuring the field and its apparent weakness relative to Earth's field. Was it left to man to exploit induced EM fields indirectly, in clinical imaging? Is it likely that natural selection did not fully, directly and efficiently exploit a fundamental physical phenomenon, induction? It was reported recently that the energy for central nervous system (CNS) myelin production, maintenance and operation costs more than that saved by 'jumping' of potential [10]. It was also argued [11] that the peripheral myelinated axon's electric field threads the myelin wrapping and induces a secondary electromagnetic field which in turn influences axon membrane, flow, content and the extracellular environment. Could secondary induction in the brain also have been selected, but for a function quite different to that proposed peripheral role? The technology capable of measuring even very weak fields opens the way to a novel concept.

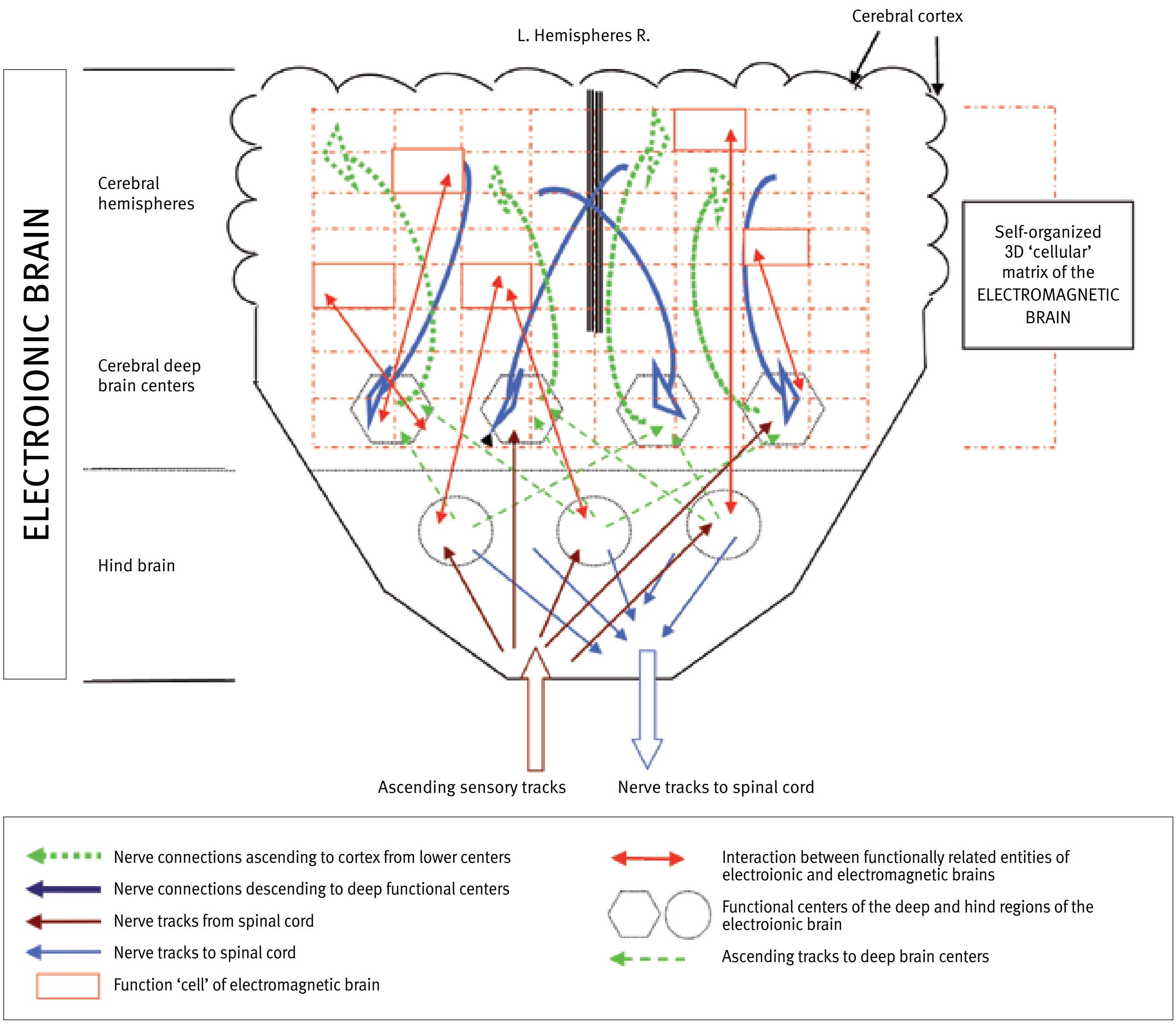
THE TWO-BRAIN HYPOTHESIS

The animal 'brain' evolved as two fundamentally different though interdependent organs: one possibly more archaic, electroionic, tangible, known and accessible; the other electromagnetic, intangible, currently unidentified and difficult to access. Natural selection will have ensured normally efficient, anatomic, metabolic and functional integration of the two brains [Figure 1]. Unlike a dependent, patterned EM field [9], the hypothesis conceives a stable, structured but flexible 3D grid of specialized regions of EM field arising from and interacting closely with specific counterpart regions of the electroionic brain. We propose the structure evolved as an independent, functional, internal integration of magnetic fields separately induced and formed by axon, dendrite and oligodendrocyte electroionic activity, according to the particular characteristics of their respective electric fields, e.g., frequency. Self-organized, EM small-world networks were first modeled in 1998 as dynamic, artificial and neural constructs in a simple nematode [12]. The model exhibited enhanced signal-propagation speed, computational power and synchronizability. Networks without material topological structure can be of this type [12].

THE IMPACT OF NEWER METHODOLOGIES

Direct, spatially and temporally accurate MRI measurement of brain magnetic neuronal activity is now possible: 3D magnetic fields (represented by vortex-like clouds of vectors in Figure 1 of reference [13]) correspond to simulated dendrite electrical activity in monkey pyramidal cells. Appropriate to the CNS scale, the vortices (experimental and simulated) range from 10 to 300 nm

Figure 1. A schematic expression of the Two-Brain Hypothesis according to which an electroionic and an electromagnetic brain interact together as independent but complementary organs, thereby enhancing higher processes of recall, perception, thought, judgment and decision in a process engendering a uniquely individual consciousness



and allow possible storage of data in the sub-unitary structure of arboreal, dendritic masses with their electrically induced magnetic fields. Diffusion MRI notes that cerebral white matter in humans and four primate species is not a chaotic mass of brain axons, as thought, but rather an orderly, dense crisscrossing at 90 degrees of parallel layers of axons, side by side, with some intertwined [14]. Grid structure in all orientations is maintained at scales from single small voxel to hemisphere, implying a possible wide additional source of brain EM vortices.

Vortex spin direction and core polarity are well-known sources of EM fields [15,16], switchable by the very low levels of field and frequency change associated naturally with, and by external application to the nervous system [15]. A 3D matrix of such vortices in the brain may enable natural digital mechanisms analogous to magneto-electronic, random-access memories and processors. Thus, a by-product of the evolving layered wiring architecture of the electroionic brain may have been increased overall brain activity, with the possible advantage of relatively less extra demand on the cardiovascular system for gaseous exchange and heat removal. Data handling as above may also have become much faster.

THE EVOLVING IMPORTANCE OF SPEED OF RECALL AND THOUGHT

Increased speed in the EM brain, parallel to selection for long-term memory, would constitute a major advantage for those surviving long enough to benefit. Speed of access to memory storage must increase, as data quantity balloons in ratio with evolving capacity for perception, analysis, judgment, action and communication, while increasing accuracy of recall would be vital for improving performance and preventing energy waste by any randomly mistaken activity. In this, the EM brain may have an advantage in stability over one based solely on chemical pathways. Though originating in and maintained by the latter, the EM organ may be less prone to attrition than the labile, chemically based processes of short-term memory. However, dissonance between the two brains could also have clinical consequences for quality of long-term memory, and beyond.

The speed adequate for motor reactions is greatly multiplied in thought. It is suggested that the speed of electroionic signal propagation, electric synapses through CNS gap junctions, and tuned-up neurons in the *Caenorhabditis elegans* hermaphrodite could not provide speeds for the advanced working human brain as does the EM brain. Though differences in function between the two brains do not exclude their overlap or even similar activity, the electroionic brain evolved initially and primarily for action and reaction, and the EM brain for rapid, complex analysis and intricate formulation.

WIDER CONSEQUENCES?

Speculatively, the evolution of language and cognition may have lessened the development of inter-personal communication in the human EM brain; this would be unlikely in other vertebrates, e.g., in marine communication, or swarming, especially where chemical communication could be ineffective. Pocketts' view that EM-based animal consciousness extends across the universe [17] may be realistic on a far more modest scale. Synchronized firing of individual avian EM brain neurons in great swarms may create relatively powerful extracorporeal EM fields. These may assist migrating animals with unrecognized navigational mechanisms, or they may be influenced by power pylons and radio masts, as suggested by many photographs of avian swarming. Not least, this hypothesis could suggest possible answers to currently unexplained clinical and other human phenomena.

CONCLUSIONS

The Two-Brain Hypothesis is proposed as a stimulus to the fundamental rethinking and research required to cope with urgent CNS clinical issues. It also provides a novel thesis for debate. Mindful that 3D spatial mapping in the rat brain was once decried [18], and against a background of deep concern for the future of mankind, it is encouraging that state-of-the-art techniques [13,14,19-23] that employ modern physics for measuring, simulating and interpreting endogenous brain electromagnetic fields are now available for clinical research. The Two-Brain Hypothesis should be included in this research.

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"The luck of having talent is not enough; one must also have a talent for luck"

Hector Berlioz (1803-1869), French composer