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► **To cite this version:**

Giuseppe Iurato. From “Entropy, Externality and Human Evolution” to “Radiator Theory of Brain”: a Very Short Review. *Journal of Neuroscience and Neurological Surgery*, 2021, 9 (4). <hal-03381415>

HAL Id: hal-03381415

<https://hal.science/hal-03381415v1>

Submitted on 16 Oct 2021

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From “Entropy, Externality and Human Evolution” to “Radiator Theory of Brain”: a Very Short Review

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Abstract. This very brief communication is aimed to highlight some recent contact points between neurosciences and dynamical system theory, passing through paleoneurology, with some remarks suggesting further possible interdisciplinary developments.

In [1], it has been considered some possible applications of non-equilibrium thermodynamics to biological systems, with a particular attention to evolution of human being, and making appeal also to socio-humanities (like anthropology, sociology, cliodynamics). From this interdisciplinary discussion, some other possible consequences, from the neuroscience side, have been drawn from either the ontogenetic and the phylogenetic standpoint. To be precise, considering formally human nervous system as a dynamical system, hence subject to thermodynamical roles and laws, it has been inferred possible ways by which climate changes, as well as meteorological variations, more or less may influence the normal and regular functioning of some basic biological components of central nervous system, above all forebrain structures, with a particular attention to hypothalamus. So, the paper argues on the possible relations between chief midbrain/forebrain structures of human brain and neuroendocrinological system, as influenced by climate changes and meteorological variations from the thermodynamical standpoint.

The hypothalamus is a fundamental forebrain structure which regulates the biochemical bases of human psyche, so it is a central component of psychosomatic system [2]. It may be considered as a particular dynamical system from the formal viewpoint, whose vital function is that said to be *homeostasis*, a crucial neurovegetative function; hypothalamus, with pituitary and endocrinological glands, gives rise to neuroendocrinological system but, at the same time, rules basic motivational and emotive functions as well as stress responses [3-11]. So, [1] considers, on the basis of what non-equilibrium thermodynamics says about the rapid variation of initial or boundary physical conditions (as occur in climate changes and meteorological variations), the neuroendocrine system (and the hypothalamus for first) as a dynamical system ruled by non-equilibrium thermodynamics, hence undergoing its rules and laws, from which then to infer possible explanations of certain neurological phenomenology, like *meteoropathy*. At the same time, in the paper has also been mentioned the possible relationships between human evolution and some chief notions of non-equilibrium thermodynamics, like entropy and the breaking of time symmetry, so pointing out their occurrence during the crucial bifurcation from primitive societies to civilized ones, which has besides given rise to the transition from a cyclic time to a linear one, typical of the modern societies.

On the one hand, if one looks at the neurobiological bases of time perception, then we observe that even invertebrates have a time perception which may also be quantified per intervals. So, if we refer to the so-called "*triune brain*" evolution model of Paul D. Maclean, along the biological line of evolution of living beings, one may argue on what possible changes have occurred along the human brain evolution from the rhombencephalic structures (typical of invertebrates), to mesencephalic ones (typical of mammals), until up prosencephalic components, above all their telencephalic parts, typical of human beings. Thus, we may infer that only these latter have conferred a more *symbolic* (or qualitative) meaning to time, besides its typical quantitative nature (which is a feature present,

along the biological evolution line, from invertebrates to mammals), with the crucial passage from nature to culture. Hence, the above mentioned passage from the cyclic time to the linear one, with its enriched variety of meanings (culture), may be put into correlation with the rising of the neocortex structures.

Furthermore, having made reference to certain thermodynamical properties of complex dynamical systems to possibly explain human evolution, is also in agreement with some past hypotheses on the brain evolution based on the so-called *radiator theory* of brain due to the works of Dean Falk [12] and Konrad Fialkowski [13-14], where they put forward the main hypothesis according to which brain evolution of primitives might have been due to evolutionary adaptation responses to increased heat stresses and consequent temperature regulation which, in turn, entailed a rewiring of blood vessels net of human brain during its phylogenetic evolution. And the crucial role played by heat stress on human brain evolution has been supported by other studies carried out in the molecular biology context of gene expression [15], which might then be put into further consideration with the fact for which the presence of NBPF HORs (i.e., neuroblastoma breakpoint family gene higher order repeats) is what distinguishes human from chimpanzee brain [16]. Likewise, a further, interesting interdisciplinary research line should take into account some other outcomes of biology and dynamical system theory intertwinement, as those mentioned in [17-18].

Acknowledgments. The author wishes to thank anonymous referees for having kindly provided very useful and remarkable insights and suggestions, which have been taken into account in this last revised form of such a very brief communication.

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