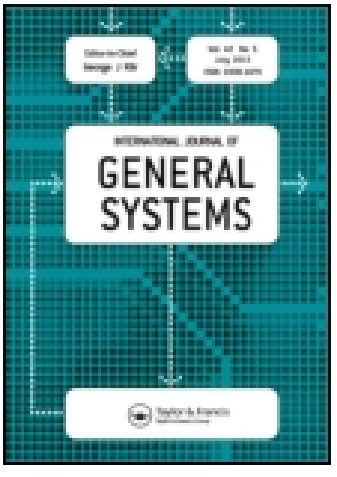

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From Russia with Love / Russian experimental and empirical contributions informed by an anticipatory perspective

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A (SPLIT) GUEST EDITORIAL

From Russia with Love

There is a reason for appropriating the title of the James Bond movie. But first, a bit of background:

The date was 25 October 2011. At the invitation of professor Dr Peter Koenig, I gave a lecture at the Institute of Cognitive Science, University of Osnabrück on a particular subject inspired by my research: quantifying anticipatory characteristics. Those who were present might remember that a student, with an obvious Russian accent (sorry, it did not sound Estonian), challenged my culture of the subject. "There were others", he let me know, "who had worked on anticipation before Rosen, before you, and even before some of the authors that you brought to the attention of the scientific community". This was, I thought, in reference to the large Annotated Bibliography published in this journal (volume 39 issue 1, 2010). I was happy to hear him mention some authors. (I knew only about Nikolai A. Bernstein, but not enough even about him). The rest is history: I initiated a Study Group on anticipation at the prestigious Hanse Institute for Advanced Study and worked hard to make a series of conferences dedicated to foundations happen. The Russians came to Delmenhorst. I had a tough time handling some of them, but all in all I learned a lot about a part of the history of science that rarely gets mentioned.

James Bond would pause here before exposing the "criminal". The student who challenged me is Andres Kurismaa, an exceptional intellectual fully dedicated to his academic focus – broader, I hasten to say than that of most my students (past and present). In his own words:

> After finishing BA studies in Semiotics at Tartu University, I spent a year studying cognitive sciences at St Petersburg State University, with special interest in Russian/Soviet schools of integrative neuroscience and psychology. While continuing studies in the Cognitive Science program of the University of Osnabrück, I integrated some of these issues in my MSc thesis on the biosemiotics of Friedrich S. Rothschild. In future work, I hope to address the relevance of these earlier traditions to contemporary cognitive science and semiotics.

Andres Kurismaa worked directly with the authors present in this issue.

The opportunity to dedicate an issue of the Journal to contributions from colleagues who were either cut off from scientific dialogue or who could not position their interests within the broader scientific context speaks to George Klir, the outgoing Editor-in-Chief, and about the publication as such. My respect is only a small token of the gratitude he deserves. I was happy to work on this issue, writing my own contribution (pleading for foundational research in anticipation).

Not even Sean Connery could wish for a happier ending. It is an honour to invite Andres Kurismaa to introduce the authors with whom he worked for a rather long time (and sometimes under strong pressure). In doing so, I want to signal to other authors, young and no longer so young, that, on matters related to anticipation, they will find in him an interested colleague. Yes, the Journal will continue to publish on issues of anticipation under the leadership of Radim Belohlavek, not the least reason being that Robert Rosen found the systems perspective that defines our publication appropriate.

At this juncture in the introduction, I pass responsibility and recognition to Andres Kurismaa. When it comes to anticipation, the Journal is more interesting than the movies of our time (James Bond or not). Of course, the drama surrounding the subject continues to unfold.

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INTRODUCTION

Russian experimental and empirical contributions informed by an anticipatory perspective

In recent years, researchers have (usually independently) come to address the problem of anticipation as in one or another way fundamental to their inquiries across a large variety of disciplines and problems in biology, medicine and cognitive science (Nadin, forthcoming-a, forthcoming-b). An annotated bibliography on the broad subject matter of anticipation – i.e. the ability of *prospective control* and future modelling in complex systems – testifies to the growing interest among scholars in anticipatory systems (Nadin 2010), even while the particular frameworks and conceptual approaches addressing it have so far remained relatively little integrated, and often proceed with little or no cross-disciplinary and systematic efforts informed by earlier inquiries.

The current issue seeks to fill a particular aspect of this gap, as this pertains to the wide-scale studies on anticipation and related problems in earlier Russian/Soviet scientific schools. While an extensive treatment of this subject, with special reference to cognitive systems and neuroscience, is available elsewhere (Nadin, forthcoming-c), the present special issue focuses mainly on problems of broader systems-theoretical and fundamental biological investigation – including the problem of anticipation in evolutionary and developmental biology (Igamberdiev; Geodakyan; Kurismaa); problems of biological equilibrium (Igamberdiev; Pavlova; Tsytolovsky); and computation in anticipatory systems (Igamberdiev; Tsygankov). The main concern of these perspectives lies in their common attempt to approach the nature and principles of biological and cognitive processes from a unifying perspective – a problem which has so far remained largely beyond current frameworks (Deacon 2011; Barandiaran and Moreno 2008), but can be seen gaining more mainstream attention along with the problem of anticipation itself (Nadin, forthcoming-a).

This issue includes both broad methodological perspectives and overviews (Nadin; Igamberdiev; Kurismaa), as well as relatively detailed technical presentations of problems relevant to the field (Tsygankov; Kalninsh and Pavlova). The majority of articles fall in between the two categories and present both original experimental/empirical materials and the conceptual perspectives informing them (Tsitolovsky; Tsygankov; Pavlova; Geodakyan). Not all authors proceed in their analysis from an explicit consideration, less a systemic and formal theory, of anticipation – as this was substantiated and sought in the early theoretical approaches to anticipatory systems in the West (Rosen [1985] 2012; Nadin 1991). Instead, more in line with the highly diverse developments characterizing modern research proceeding with different methods and motivated by different empirical concerns, the issue offers a glimpse of different research traditions, united more by their systematic pursuits in integrating

basic biological and cognitive enquiries rather than any particular object or method in the narrow sense. The broad identifier of these diverse works is the problem of temporal and relational organization and modelling of biosystems, with particular emphasis on anticipation.

Recent studies on the adaptive strategies and analyses of environmental events in micro-organisms (Freddolino and Tavazoie 2012), plants (Novoplansky, forthcoming), as well as invertebrate organisms (Brembs 2011) indicate that the categories traditionally reserved for higher metazoan nervous systems and cognitive processes (e.g. decision-making, anticipation) may have significantly older evolutionary roots. And indeed, understanding the basic organization of living systems may prove impossible without a theory of anticipation and cognition. Perhaps some of the most striking evidence for this was obtained in the studies and experiments on microbial behaviour and its laboratory evolution (Tagkopoulos, Liu, and Tavazoie 2008; Mitchell et al. 2009), where adaptive genome-wide transcriptional reprogramming was shown to modify anticipated sequences of environmental events through epigenetic processes over relatively short periods (in evolutionary terms). In numerous cases, micro-organisms were shown to mobilize functions that represent a voluntary risk to their current or short-term homoeostasis. They seem to be directed to the possibility of a future gain, clearly indicating the need to complement classical reactionary and homoeostatic models of behaviour with anticipatory ones in respect to basic behavioural, epigenetic and evolutionary processes (Freddolino and Tavazoie 2012). These authors propose that the plastic and dynamically evolving internal representation of environmental correlations within micro-organisms – i.e. in the organization of their genetic regulatory networks – demonstrates that monocellular biochemical networks are capable of anticipatory and predictive behaviour in a manner that is, in principle, similar or comparable to that of metazoan nervous systems (Tagkopoulos, Liu, and Tavazoie 2008; Freddolino and Tavazoie 2012). Thus, anticipation may be a key factor to be considered in analysing the evolutionary and epigenetic processes expressed in organisms' biochemical and physiological organization, and how the latter relates to particular natural habitats.

In the current issue, Abir Igamberdiev shows how the notion of internal anticipatory modelling in biosystems can be grounded beyond conventional probabilistic approaches – as generally conceived and proposed in the above studies – and be interpreted in respect to the basic non-equilibrium dynamics and quantum processes in biosystems. Among other sources, this approach builds on the works of Russian/Soviet theorists Ervin S. Bauer and Efim A. Liberman, known, respectively, for their formulations on the principle of "stable non-equilibrium" and the theory of molecular cell computer as basis for living systems' anticipatory capacities. Drawing on and extending the classic and modern works of both Russian/Soviet and Western traditions, Igamberdiev defines the contributions of a number of leading authors and schools in constructing a general theory of anticipation; he outlines as well its modern context in empirical evolutionary and biophysical research.

An original approach to the preconditions of anticipation in the "living state of matter" and its non-equilibrium dynamics is developed by Vladimir Tsygankov in the framework of his neurocomputer paradigm "Embryo", introduced here as a virtual model of the living. Based on the works of G.N. Ling, E.S. Bauer and P.K. Anokhin, it is shown how the basic bioenergetic and biophysical processes underlying the living state can be mapped to the (anticipatory) parameter space and basic functional blocks of the neurocomputer, thus enabling to model transitions in the non-equilibrium state of the living system (and its "biological field", i.e. ultraweak biophysical emission). The interesting connection between Ling's modern approach to the "living" and "death states" of matter, and the early work by D.N. Nasonov and N.E. Wedensky is discussed. Both lines of research have served as sources for

modeling non-equilibrium states on the neurocomputer, as well as the biophysical preconditions of anticipation.

With a similarly strong basis in the neurophysiological schools of Anokhin and Wedensky, Lev Tsitolovsky develops a view of homoeostasis in neuronal systems as a goal-directed and anticipatory process. In this approach, the self-regulation of cellular (neuronal) functions is seen as being directed against actual or anticipated functional damage, processed self-referentially by the system as a qualitative estimation of its own condition. It is shown how, in case of deviations, the condition is corrected based on free search for an optimal (adaptive) goal-state, minimizing homoeostatic mismatch. Tsitolovsky's works suggest a mechanism whereby this goal-directed search can be achieved if the fluctuations of a system's instability increase together with growing deviations of the quality criterion from the system's self-defined optimal state. Though there is no guarantee yet that the described mechanism is implemented in the nervous system, it offers a principled possibility of explaining goal-directed choice through free search, along with the proposal that the existence of free will is not inconsistent with the laws of nature. The apparatus of generalized Lagrangian dynamics developed recently by Tsitolovsky's co-worker Uziel Sandler is seen by the author as offering a new potential tool for describing the search of optimum state in living homoeostatic/anticipatory systems.

Lucia Pavlova's paper presents a different approach to analysing the non-equilibrium dynamics of human brain states based on the neurophysiological concepts of the Wedensky–Ukhtomsky school, with particular focus on extending Ukhtomsky's concept of dominance to human electroencephalographic and systemic psychophysiological research (Pavlova, forthcoming-a, forthcoming-b). In close resonance with Bauer's principle of stable non-equilibrium of living systems, and based on Wedensky's concept of non-linear functional state changes (informing also Tsitolovsky's work), Pavlova analyses the progressive psychophysiological transformations and functional state changes underlying human work capacity, problems of lateral functional asymmetry, as well as complex cognitive anticipatory and creative abilities of the human mind-brain. Introducing novel methods of EEG analysis and human functional state assessment and correction, Pavlova's works can be seen as grounding an original and integrative framework of systemic human psychophysiology, based equally on general biological concepts and recognition of the social mediation of human psychophysiological processes.

The evolutionary theory of asymmetry by Vigen Geodakyan, as summarized by his collaborator and son Sergey Geodakyan, explains from a unified position numerous phenomena associated with sexual dimorphism and the asymmetry of the brain, hands and other paired organs in animals and humans. Interestingly, it can be seen to offer independent confirmation of Pavlova's conclusion regarding the temporal dynamics of functional lateralization and anticipation (the translocation of novel functions/information from left frontal brain regions to posterior right areas in the course of habituation/evolution). Geodakyan's evolutionary theory of sex and asymmetry are based on the principle of conjugated systems that evolve asynchronously in time and space. This means that any new function or trait that appears in the organism or population is at first assimilated only in its "operative" subsystem, before the feature becomes maintained and is propagated as a permanent adaptive solution to some biological task in the conservative subsystems of the body and population. This principle of "asynchrony" raises the question of whether it may represent a principle by which organisms are able to model their own possible future developmental and evolutionary courses, as the conservative subsystems change on a slower time-scale and only after the provisional or "anticipatory" (pre-)adaptations of the operative systems have proven effective. By approaching the different temporal dynamics of organisms' evolution, development and behaviour from a systemic perspective, the theory creates prospects for further integration of theoretical biology

and diverse areas of applied research in biology, medicine, psychology and social sciences, as briefly outlined in Geodakyan's paper.

Andres Kurismaa further considers the problem of anticipation from an evolutionary and systems-theoretical perspective. He proposes that, as with the current analyses and recognition of the early contributions of Russian/Soviet schools to the field of evolutionary developmental biology, a similar consideration of the fields of neuroscience and anticipation research awaits its turn (Kurismaa, forthcoming). This may be particularly pertinent, as the latter fields proceeded from a closely related organismic, or evolutionary developmental biology perspective and addressed problems of epigenetics that have risen to the forefront of biology and neuroscience relatively recently, and to our knowledge have not been widely addressed in frameworks of anticipation. In addition to briefly outlining the theoretical and systematic conceptual background on which problems of anticipation were first formulated in the Russian/Soviet schools of life and mind sciences in the early and mid-twentieth century, and the contemporary context of their possible (renewed) relevance, some of the key positions of Anokhin's functional systems theory are presented. It is proposed that its epigenetic interpretation of anticipation as a basic evolutionary adaptive mechanism and organizational feature of life is well in line with and confirmed by recent independent research.

In the last paper, Karl Kalninsh and Lucia Pavlova present materials supporting their hypothesis of water as an active catalytic medium, which, through its role in enzymatic reactions, supports life's anti-entropic processes, including the anticipatory capacities of biosystems. The electron–proton effect of chemical reactions discovered by Kalninsh was used as a basis for developing a rapid analytical procedure allowing evaluation of the chemical reactivity of water and assessment of its biological activity on organisms. Further studies indicate that water possesses catalytic properties and significantly accelerates catalytic biochemical reactions, considered by the authors for the first time from the viewpoint of thermal electronic excitation. This approach is presented in its theoretical and technical aspects. Additionally, historical background and facts are given, which enable tracing the evident continuity of the presented approach with Vernadsky's notions of living matter and origins of life, as well as the analogous ideas and achievements of the well-known Russian biochemist Alexander I. Oparin and biophysicist Ervin S. Bauer. Finally, the relation of presented views to the development of anticipatory representation on the basis of catalytic processes as proposed by Anokhin is discussed (cf. Kurismaa, current issue).

Naturally, within the limits of this issue it is possible to address only a very limited number of aspects and earlier traditions relevant to anticipation research. It will no doubt be a long-standing task to consider the research addressed in this journal issue from the foundational perspective underscored by Nadin (current issue), and to analyse its relevance and modern position in the theoretical framework of anticipation as thoroughly as is evidently called for. However, that this task will prove to be rewarding is hopefully shown beyond doubt by the numerous contributions present in this special issue. Further studies will hopefully facilitate addressing numerous important omissions, including the classic legacies of biologists Karl von Baer, Alexander Gurwitsch and the physiologist Nikolai Bernstein (Nadin, forthcoming-c). Likewise, the works of numerous important authors such as Liberman and Bauer have been only briefly highlighted in this issue – hopefully to stimulate further analyses in the future.

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References

Barandiaran, X., and A. Moreno. 2008. "On the Nature of Neural Information: A Critique of the Received View 50 Years Later." *Neurocomputing* 71 (4–6): 681–692.

Brembs, B. 2011. "Towards a Scientific Concept of Free Will as a Biological Trait: Spontaneous Actions and Decision-making in Invertebrates." *Proceedings of the Royal Society B: Biological Sciences* 278: 930–939.

Deacon, T. W. 2011. *Incomplete Nature: How Mind Emerged from Matter*. New York: WW Norton & Company.

Freddolino, P. L., and S. Tavazoie. 2012. "Beyond Homeostasis: A Predictive-dynamic Framework for Understanding Cellular Behavior." *Annual Review of Cell and Developmental Biology* 28: 363–384.

Kurismaa, A. Forthcoming. "Perspectives on Time and Anticipation in the Theory of Dominance." In *Anticipation: Learning from the Past – The Legacy of Soviet/Russian Scientists*, edited by M. Nadin. Cognitive Systems Monographs. Cham: Springer.

Mitchell, A., G. H. Romano, B. Groisman, A. Yona, E. Dekel, M. Kupiec, O. Dahan, and Y. Pilpel. 2009. "Adaptive Prediction of Environmental Changes by Microorganisms." *Nature* 460 (7252): 220–224.

Nadin, M. 1991. *Mind – Anticipation and Chaos*. Stuttgart: Belser Presse.

Nadin, M. 2010. "Annotated Bibliography. Anticipation." *International Journal of General Systems* 39 (1): 35–133.

Nadin, M., ed. Forthcoming-a. *Anticipation: The Interdisciplinary Perspective*. Cognitive Systems Monographs. Cham: Springer.

Nadin, M., ed. Forthcoming-b. *Anticipation and Medicine*. Cognitive Systems Monographs. Cham: Springer.

Nadin, M., ed. Forthcoming-c. *Anticipation – Learning from the Past: The Legacy of Soviet/Russian Scientists*. Cognitive Systems Monographs. Cham: Springer.

Novoplansky, A. Forthcoming. "Future Perception in Plants." In *Anticipation: The Interdisciplinary Perspective*, edited by M. Nadin. Cognitive Systems Monographs. Cham: Springer.

Pavlova, L. P. Forthcoming-a. "Dominance Principle and Creativity in Human Brain Functions." In *Anticipation – Learning from the Past: The Legacy of Soviet/Russian Scientists*, edited by M. Nadin. Cognitive Systems Monographs. Cham: Springer.

Pavlova, L. P. Forthcoming-b. "Individuality of Brain Dominants as a Problem of Special Education and Pedagogy." In *Anticipation – Learning from the Past: The Legacy of Soviet/Russian Scientists*, edited by M. Nadin. Cognitive Systems Monographs. Cham: Springer.

Rosen, R. [1985] 2012. *Anticipatory Systems*. 2nd ed. New York: Springer.

Tagkopoulos, I., Y. C. Liu, and S. Tavazoie. 2008. "Predictive Behavior within Microbial Genetic Networks." *Science* 320 (5881): 1313–1317.