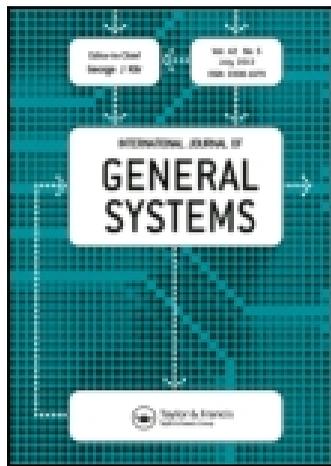


This article was downloaded by: [Mihai Nadin]

On: 03 July 2015, At: 08:06

Publisher: Taylor & Francis

Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: 5 Howick Place, London, SW1P 1WG



International Journal of General Systems

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/ggen20>

Concerning the knowledge domain of anticipation - awareness of early contributions in the context of defining the field

Mihai Nadin^a

^a antÉ - Institute for Research in Anticipatory Systems, University of Texas at Dallas, Richardson, TX, USA

Published online: 02 Jul 2015.



CrossMark

[Click for updates](#)

To cite this article: Mihai Nadin (2015) Concerning the knowledge domain of anticipation - awareness of early contributions in the context of defining the field, International Journal of General Systems, 44:6, 621-630, DOI: [10.1080/03081079.2015.1032524](https://doi.org/10.1080/03081079.2015.1032524)

To link to this article: <http://dx.doi.org/10.1080/03081079.2015.1032524>

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the "Content") contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms &

Conditions of access and use can be found at <http://www.tandfonline.com/page/terms-and-conditions>

Concerning the knowledge domain of anticipation – awareness of early contributions in the context of defining the field

Mihai Nadin*

antÉ – Institute for Research in Anticipatory Systems, University of Texas at Dallas, Richardson, TX, USA

(Received 20 October 2014; accepted 15 January 2015)

The knowledge domain of anticipation is still in the process of being defined, and is therefore subject to controversies. Science was never an endeavour of consensus but rather of debate. This additional argument to the debate integrates awareness of the early Soviet/Russian contributions to a science of anticipation. From this awareness derives the understanding of why anticipation faces opposition from established viewpoints. This article ascertains that anticipation advances a fundamental view of the living. Within this view, anticipation is always expressed in action. Short of this definitory condition, anticipation fades into the grey mass of speculative predictive methods.

Keywords: action; anticipation; change; possible future

An issue of legitimacy

The international conference *Anticipation – Learning from the Past. Early Soviet/Russian contributions to a science of anticipation* (September 2014, Delmenhorst) was conceived with the express goal of bringing to the attention of those interested in the knowledge domain of anticipation the work of exceptional scientists who were, without any doubt, pioneers in the field. To understand what their work means, we need to define a perspective, which will serve to frame anticipation in the current context.

It was said that if Germany, through the murderous Nazi regime, had not lost its Jews – many killed, some survived by seeking refuge elsewhere – the country would probably be a superpower today. (In some respects it is, because although it lost the war, it won the peace.) It can be said that if the Soviet Union had not, from time to time, brutally oppressed its Jews (not only Jews were oppressed, of course), moreover if the Soviet Union's breakdown had not triggered the haemorrhage of talent (with many Jews, but not only, seeking better working conditions abroad), the USSR or Russia (even without the republics that gained independence) would still be a superpower. The countries forming the Soviet Bloc (as it was called) were affected as well. Many of the emigrants are by now members of academia (and sometimes of Academies) in the USA, Great Britain, France and Germany; some are working in the Middle East; and some are the new venture capitalists who push the fast pace of today's technological renewal.

These introductory lines, not about Jews or any other groups that suffered under communism (or under fascism), will not remain unchallenged. In reality, the majority did not identify with a religion, or even with a culture different from that of the Soviet Union (or of Germany

*Email: nadin@utdallas.edu

under fascism, for that matter). Regardless of how history would have played out, we know that much of the creative energy of many scientists was wasted under a substantially totalitarian regime, which did not allow their scientists the liberty of identification through their own original ideas. Their work was repressed in their countries, and not acknowledged outside for reasons of appeasement. Quite a large body of work associated with those scientists remains little known in our world to this day. Re-evaluation of their work is long overdue so that it can be made available to the extent that it remains relevant to science. Indeed, what counts is their science – and, of course, their moral standards.

In this spirit, the international conference that I organized within the framework of the Study Group on Anticipation at the Hanse Institute for Advanced Study, focused on the works of Orbeli (1923), Ukhtomsky (1923), Uznadze (1925), Vygotsky (1926), Beritashvili (1932), Anokhin (1935), Bernstein (1935), Sokolov (1963), Luria (1970) and others. But there is more to their work, which constitutes a body of knowledge waiting to be acknowledged and continued by others. Moreover, those who were not explicitly on the Conference's agenda researched subjects that belong to the broader meaning of anticipatory systems. The Conference facilitated the building of a momentum favourable to further describing the intellectual fervour of anticipation-inspired inquiry, and to disseminate it. George Klir, whose activity at the *International Journal of General Systems* cannot be praised enough, graciously offered to dedicate an issue of the Journal to contributions related to the Conference's focus. This opportunity aligns with Klir's initial openness towards Robert Rosen's publications; therefore, it invites some thoughts on what foundations are and how new ideas, in this case pertinent to anticipation, face resistance.

Darwin (1871, 3), in a book in which anticipation is incidentally present, took note of the fact that “ignorance more frequently begets confidence than does knowledge”. If the degree of success of a field of inquiry had anything to do with how often its label is used (the mantra of search engines), we could say that *anticipation* has made it. The word is in everyone's mouth – unfortunately for the wrong reasons most of the time. (Quantum mechanics and genetics seem to be cursed with similar success.) Neither is history per se, as a timeline of events – i.e. the narration – a source of scientific legitimacy. Nevertheless, when the timeline reveals successive expressions of knowledge and is substantiated by experimental evidence, legitimacy ensues on account of a successful record. Those who ignore such a record of tested and confirmed knowledge give in to the embrace of ignorance to the same extent as those who use a concept without understanding it. Their endeavours end up undermined by a confidence that is at best illusory.

Was there a Soviet School in anticipation studies?

With all this in mind, the late discovery of the “Soviet School” in anticipation is less a subject in the history of science and more an opportunity to define the meaning of anticipation. As far as I know (Nadin 2010), very few of those active in anticipation research early on were aware of the contributions coming from behind what used to be called the “Iron Curtain”. Even among those who are currently interested in the subject, there is little, if any, interest in the ideas of their predecessors from the Soviet Union – or from any other place, for that matter. Nevertheless, in establishing an encompassing science of anticipation, a foundational effort that does not integrate early contributions is simply not possible, and certainly not valid. Rosen (1991) placed anticipation in the framework of his encompassing attempt to define what life is – a fundamental subject of science and philosophy. Louie (2006, 50) defines a “Rosen's Trilogy” in this respect. My own understanding of anticipation is grounded in neuroscience. In this Journal (Nadin 2010), as well as in the Prolegomena

(Nadin 2012) to the second edition of *Anticipatory Systems* (Rosen 2012), I put Rosen's work in a broader context. The fact that self-proclaimed experts and chairs of university programmes remain, wilfully or not, ignorant of such a context comes as no surprise. When the horn of self-adulation blows loud, to hear anyone else becomes impossible. But let's not waste time with the insignificant. Rosen experienced the same disdain, and happily ignored his detractors. Unfortunately, in the Soviet Union, those whom the authorities – in politics and in science – attacked could not ignore their situation. Their livelihood was undermined.

Rosen was aware of some research and publications that preceded his work. He cultivated respect for those from whom he could learn, Rashevsky, in particular. Whitehead (1929), King (1938), Shackle (1938), Kelly (1955), Svoboda (1960), Powers (1973), Bennett (1976), among others, approach anticipation from the perspective of philosophy, anthropology, control theory, psychology or economics (Nadin 2012, xv–lx). The contributions of the Soviet-era scientists predate their writings, which are mostly couched in psychology, as well as in the study of the nervous system. In more recent times, scientists active in artificial intelligence, neural networks, adaptive learning systems and cognitive science (Balkenius, Kopp, and Pallbo 1994; Davidsson 1997; Knutson, Westdorp, and Hommer 1998; Dubois 2000; Balkenius and Johansson 2007, to name a few) joined the effort, but not so much through a preoccupation with *foundations* as with domain-specific work related to particular aspects of anticipation. The situation was not different in the Soviet Union.

Respectful acknowledgement of contributions rarely qualifies as foundational. The motivation for this special issue of our Journal is to further contribute to a *reference library* on the subject of anticipation. But if we are interested in their foundation, we'd better build on it by integrating the particular ideas they developed.

Science censorship

Establishing foundations is not an easy enterprise, especially in an age of impatience in which all that counts is the immediate “return on the investment” (often in the form of yet another start-up). At stake is the legitimacy of the anticipation perspective. Indeed, we *must* continue foundational work – even in an age when fundamental research is looked down upon. Within this ambitious endeavour, the research that took place in the Soviet Union (since ca. 1930) deserves not only acknowledgement, however tardy, but especially re-evaluation, in view of the current state of science and philosophy. In many respects, the forerunners are still ahead of us. To exemplify the thought, I will make reference to the 2014 Nobel Prize in Physiology and Medicine (Nadin 2014b).

Nobel Prizes are not conferred upon the dead (unless by accident!). The Nobel Committee broadcasted the 2014 award in Physiology or Medicine for the discovery of the “GPS” in the living (i.e. “... cells that constitute a positioning system in the brain”). It went to meritorious scholars, no doubt about that. But the fact that way before them, others defined spatial navigation cannot become a mere parenthesis in the history of science, to be ignored or forgotten. In his research, O’Keefe correctly references the work of Tolman (1948). Most striking is the fact that the work of Ivan S. Beritashvili (also known as Beritov) in the 1930s was totally disregarded by those defining the scientific context (i.e. the Nobel Prize Committee). But O’Keefe was aware of it: he had many of Beritashvili’s works translated, as he proudly informed his hosts during a visit to Beritashvili’s Institute at the University of Tbilisi, Georgia.

During the conference, Merab Tzagareli, an expert on Beritashvili, presented evidence of Beritashvili’s pioneering work in anticipation. Spatial navigation, in particular, has a strong anticipatory dimension, to this day not clarified in detail. Little did Tzagareli know that soon

after his presentation it would again become evident why we need to reassess the contributions made by scientists of the former Soviet Union. Some of them were isolated from the international scientific community; others were vilified. The reassessment is not for reasons of sympathy, or for the sake of history, or for seeking legitimacy in historic narration. It is a necessary step towards making progress in the foundation of the study of anticipation. References pertinent to the subject (Beritashvili 1927, 1932, 1959, 1963, 1965, 1966, 1969; Bures and Buresova 1990; Jensen 2006) are part of this attempt to consider contributions based on which we can further our knowledge of anticipatory processes and the role they play in defining the living.

Was the absence of Beritashvili's work a simple omission? Probably not. Bernstein's work sheds light on my evaluation. It also informs us, so many years after his painful experience, concerning the sometimes strange ways in which scientific renewal comes about, and might become subject to censorship. In a recent review of a new biography of Pavlov (Specter 2014), we read: "The Soviets came to regard Pavlov as a scientific version of Marx" (126). For those never exposed to the rules of totalitarianism, a short explanation: first the easy reference: Marx, demonized in capitalist societies, was the ideological god under communism. Ivan Pavlov, a physiologist and Nobel laureate (1904), advanced the (famous) model of conditioned reflexes (Pavlov 1927). This ascertained the central role played by the cerebral cortex. Bernstein, respectful of Pavlov's work, produced evidence of motoric activity that was not reducible to the reflex, but an expression of anticipation. I will not detail his arguments here, but rather explain that to challenge successful, though incomplete, scientific theories can be dangerous. In his biography of Bernstein, Feigenberg ([2004] 2014) goes into the details of a conflict of scientific views that was hijacked in the politics of science (anti-Semitism included). One more reference: Rose (2006, 62) mentions that the concept of autopoiesis – also related to anticipation – "reprises the earlier term, system-genesis, introduced in the 1930s by Soviet neuropsychologists, in particular P.K. Anokhin". *The Making of Memory. From Molecules to Mind* (Rose 2012) contains other examples along this line.

It will come as no surprise that similar situations are experienced in the "free world". (Rosen's biography documents this possibility.) Anticipation as a scientific construct does not fit the traditional mindset of science. Scientific censorship often means that ideas challenging established perspectives are ignored, discarded and rejected from funding opportunities. They are also omitted from publications and from the institutional structure of educational institutions. Academia sometimes imitates political power games.

Let me repeat: this special issue is intended as a reference publication. Therefore, it was not conceived as a mere addition to proceedings of a conference, or as an act of rehabilitation. It has its own justification and extends to original contributions that transcend those of the "classics". To place contributions such as those of the scientists discussed in this issue in the perspective of their relevance to a science of anticipation is a challenging task. We look back not only from the perspective of the knowledge available today, but also in full awareness of the original context. Of course, some aspects of the context in which their contributions were made usually escapes us.

A broader view: anticipation is definitory of life

I will take the opportunity to suggest a bridge between findings and views, such as those reported in this issue, and the challenging question of the condition of anticipation. For this purpose, I shall reiterate the operational definition that defines my own views: *An anticipatory system is a system whose current state depends not only upon previous states, but also upon future possible states* (Nadin 2012, xxxiv). Please note that the future in question is pertinent

to the open-ended, ever-changing space of possibilities. Within this view, pretty much consonant with Robert Rosen's conception, anticipation is a definitory characteristic of the living.

Along the timeline of individual life, there are many instances of augmented anticipatory expression. Behaviours associated with reward/punishment processes are produced as typical examples. They are usually associated with particular somato-cortical processes. As impressive as such examples are, they do not report on the complexity of anticipatory processes. In the family of suggestive examples, sexuality figures high in terms of how frequently it is used to exemplify how a *possible future* (hugging, kissing, sexual encounter) *affects a current state* (and how attractions are established). Moreover, given the fact that abiotic conditions (rainfall levels, wind velocity, barometric pressure, etc.) affect flora and fauna, some researchers have tried to infer from sexual behaviour to weather patterns (Pellegrino et al. 2013). This might sound far-fetched, but only for those who are not aware of the richness of anticipation expression (avoidance of danger, finding sources of nourishment, integration of effort and much more). Modified sexual behaviour, always driven by the anticipation of reproduction, documents the interactive nature of the relations between the living and the physical environment (to the extent that we can ever effectively distinguish between them). However, in order to grasp the depth and breadth of anticipatory processes, and the richness of anticipatory expression, it is more beneficial to point to reproduction (in humans, animals, plants, etc.).

Throughout the history of science, many descriptions, some very precise, of reproductive processes have been advanced in almost all cultures. Furthermore, spectacular progress in genetics and molecular biology, as well as in neurophysiology, has provided extremely detailed descriptions of the anticipation implicit in reproduction (e.g. Brunton and Russell 2008; Moya et al. 2014). Anatomical, physiological, emotional and other changes (such as hormonal) are associated with fertilization and early embryo formation (Figure 1).

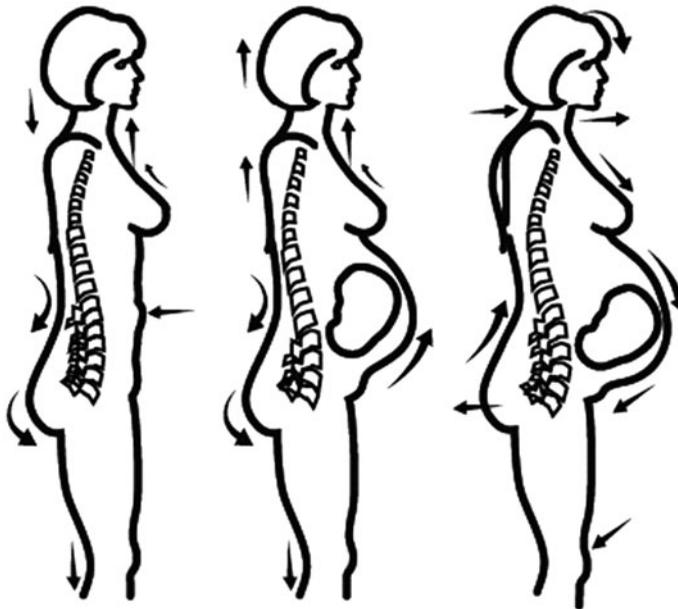


Figure 1. Anatomical changes in anticipation of pregnancy challenges.

It is a large-scale, holistic preparation, extended, in some limited way, even to the partner. (Men get “pregnant”, as well, and not only in a figurative sense.) Women who go through pregnancy have reported nausea, fatigue (usually associated with progesterone levels), heartburn, sleep deprivation, leg cramps (calcium absorption is the usual culprit, although things are more complicated than that), increased frequency of urination (the growing uterus puts pressure on the sphincter), swelling, back pain, gum disease, anaemia, etc. The skin darkens and mood swings are not uncommon. At closer look, all such symptoms – usually examined within the typical cause–effect paradigm (deficient absorption of calcium, to name the apparent cause of leg cramps) – are connected to a multitude of adaptive processes in anticipation, not in reaction, to the formation, growth and development of the foetus. The neuro-endocrine systems and the associated hormones characteristic of pregnancy are only part of the broad process of making life from the living, within a context of internal and external influences of all kind.

The complexity of the process escapes a full and non-contradictory description (Nadin 2014a). The entire process of reproduction has an internal coherence that integrates pre-fecundation, fecundation, pregnancy, parturition, lactation and maternal behaviour. If we consider only all that is involved in lactation – which is evidently anticipatory, and not in reaction to a baby’s need for the mother’s milk – one can get an image of the undecidable nature of the entire process. For the sake of example (part of the broader image), the secretion of oxytocin from the posterior pituitary gland prepares milk ejection, but also parturition, at a well-defined moment in time, by stimulating uterine contractions. The rapid onset of motherly actions and the modulation of emotions are associated with the dendrites of magnocellular neurons. The simplistic image conjured by associating fatigue with progesterone levels is complemented by understanding opioid inhibition and the action of relaxin, a pregnancy peptide hormone. In view of all this, fatigue translates as part of a larger process in which some behaviour is expressive of protective processes. Yet again, as a suggestive example: some brain processes associated with pregnancy and giving birth are short-lived, while others extend to maternity. Maternal aggression (different in animals and in humans) involves the olfactory bulbs, the amygdala, parts of the hypothalamus, etc. Olfactory memory of the newly born in the woman giving birth plays a different role than that in the ewe that has given birth. This is the classic example of how bonding takes place. Lorenz’s work of 1943 (published in English, 1952) on imprinting acquires new meaning in this anticipatory perspective.

The main reason for the example given above is that the view on anticipation that defines my perspective is probably difficult to reconcile with that of the authors present in this issue. As a matter of fact, my view remains quite distinct from that of the majority of those who claim an interest in anticipatory systems. This in itself does not qualify the knowledge expressed as more significant than that of less restrictive epistemological premises. (Some authors extend the notion of anticipation to the realm of the inorganic.) But the definition that serves as the premise for my views does establish a coherence that cannot be achieved by those willing to use the word *anticipation* for qualifying phenomena or processes such as *guessing*, *expecting*, *forecasting*, *predicting*, *planning* or *prospection* – a later concoction of dubious psychological elaboration (Gilbert and Wilson 2007; Seligman et al. 2013).

Quite a number of researchers who express interest in anticipation are under the impression that their intuitive take on the meaning suffices for their claim to competence. Moreover, they come to the subject biased through an understanding of reality as being undifferentiated. This fact goes back to the view of life that has dominated ever since *vitalism* – i.e. the notion that a clear-cut distinction between the living and the non-living is not possible – was debunked. No one dedicated to scientific rigour would go back to the primitive views contained in vitalistic thought. For research in anticipatory systems to make progress, it would be

encouraging if more scientists would debunk the primitive assumption that change in the living and in the physical are the same. Reductionism and determinism served well for the acquisition of knowledge under circumstances of relatively slow change. By now, they are rather unproductive simplifications that prevent a better understanding of the dynamics of the living.

In a rather provocative study, Verstack et al. (2014) produce data on “the growing impact of older articles”. Of course, in considering the Soviet School, “older” cannot mean 15 years, but rather around half a century ago, which Scholar Metrics (used by the Verstack “group” of Google data-mining) still ignores. On the shoulders of the “giants” introduced in the volume dedicated to the Soviet/Russian study of anticipation (Nadin 2015), and in this special issue of our Journal, the quality of future scholarship in anticipation will be augmented. The broad intellectual map of theories and experiments is indicative of a convincing progression from observation to a slowly emerging, distinct body of knowledge that escapes the traditional reductionist model of the experience. Anticipation cannot be reduced to physics, or to psychology, physiology or any other field of knowledge. It has ascertained its own domain of knowledge. It comes to expression in open systems; therefore, mappings to closed experiments and inferences from such experiments to reality are not productive. The conference, together with the printed contributions of many distinguished researchers, is yet another instance in the process of sharing knowledge. It is my hope that through this issue of the *IJGS*, we are offering access to information of relevance that was not yet fully integrated in the scientific awareness of our time.

Disclosure statement

No potential conflict of interest was reported by the author.

Notes on contributor



Mihai Nadin’s interests and professional life combine engineering, mathematics, digital technology, semiotics, mind theory and anticipatory systems. He holds advanced degrees in Electrical Engineering and Computer Science and a postdoctoral degree in Philosophy, Logic and the Theory of Science. Since 1985, he has dedicated his research to anticipation/anticipatory systems. His book *Mind – Anticipation and Chaos* (1991) advanced a dynamic systems perspective of anticipatory processes. Research in dynamic systems at Stanford University and UC–Berkeley led him to further probe anticipatory systems: “Anticipation – A Spooky Computation”, “Anticipating Extreme Events: The Need for Faster-than-real-time Models” and the book *Anticipation – The End Is Where We Start From* (which set a foundation for the field in lay terms). He established the antÉ – Institute for Research in Anticipatory Systems (2002) as a research “think tank”, and consulting entity (for technical innovation, business, policy development, game-based simulations and defence). It became part of the University of Texas at Dallas (2004) when he accepted its invitation to become Ashbel Smith University Professor. Recent publications on anticipation include: “Quantifying Anticipatory Characteristics” (2013); “The Intractable and the Undecidable – Computation and Anticipatory Processes” (2013); “G-Complexity, Quantum Computation and Anticipatory Processes” (2014). He was named Honorary Fellow of the Hanse Institute for Advanced Study (Germany), where he initiated *Anticipation Across Disciplines*. This study group (with support from the Thyssen Foundation and the German Science Foundation/DFG) organized two international conferences in 2014. The third, “Anticipation and Medicine”, will take place in September 2015. For more information, see <http://www.nadin.ws>, <http://www.anteinstitute.org>, <http://www.nadin.ws/ante-study/>.

References

- Anokhin, P. K. 1935. The Problem of Center and Periphery in the Contemporary Physiology of Nervous Activity. In *The Problem of Center and Periphery in the Physiology of Nervous Activity*, edited by P. K. Anokhin, 9–70. Moscow: Gosizdat Gorky.
- Balkenius, C., and B. Johansson. 2007. “Anticipatory Models in Gaze Control: A Developmental Model.” *Cognitive Processing* 8: 167–174. doi:10.1007/s10339-007-0169-8.
- Balkenius, C., L. Kopp, and R. Pallbo. 1994. “A Robot with Autonomous Spatial Learning: A Project Overview.” In *Proceedings of SAIS’94*, edited by R. Sillen. Ronneby: NovaCast AB.
- Bennett, J. W. 1976. “Anticipation, Adaptation, and the Concept of Culture in Anthropology.” *Science* 192 (4242): 847–853.
- Beritashvili, I. S. (I. S. Beritov). 1932. *Индивидуально-приобретенная деятельность центральной нервной системы* [Individually Acquired Activity of the Central Nervous System]. Tiflis: State Printing House of Georgia.
- Beritashvili, I. S. (Beritoff). 1959. *О нервных механизмах пространственной ориентации высших позвоночных животных* [Nervous Mechanisms of Spatial Orientation of Mammals]. Tbilisi: Georgian Academy of Sciences Press.
- Beritashvili, I. S. 1961. *Нервные механизмы поведения высших позвоночных животных*. Moscow: AN CCCP. Published in English 1965 as *Neural Mechanisms of Higher Vertebrate Behavior*. Translated and edited by W. T. Liberson. Boston, MA: Little Brown.
- Beritashvili, I. S. (Beritov). 1963. “Les mécanismes nerveux de l’orientation spatiale chez l’homme.” [The Nervous Mechanisms of Spatial Orientation in Man.] *Neuropsychologia* 1: 233–249.
- Beritashvili, I. S. (Beritoff). 1966. “Prefatory Chapter: From the Spinal Coordination of Movements to the Psychoneural Integration of Behavior.” *Annual Review of Physiology* 28: 1–17.
- Beritashvili, I. S. 1969. “Concerning Psychoneural Activity of Animals.” Chap. 2 in *A Handbook of Contemporary Soviet Psychology*, edited by M. Cole and I. Maltzman, 627–670. New York: Basic Books.
- Beritoff, J. S. 1927. “Über die individuell-erworbene Tätigkeit des Zentralnervensystems” [On the Individually Acquired Activity of the Central Nervous System]. *Journal of Psychological Neurology* 33: 113–335.
- Bernstein, N. A. 1935. “Das Problem der Wechselbeziehungen zwischen Koordination und Lokalisation” [The Problem of the Interrelationships between Coordination and Localization]. In *Bewegungsphysiologie von N.A. Bernstein*. 2nd ed., edited by L. Pickenhain and G. Schnabel, 67–98. Leipzig: Johann Ambrosius Barth. [Original work published in Russian: Проблема взаимоотношений координации и локализации. Архив биол. наук, Vol. 38 (7).]
- Brunton, P., and J. Russell. 2008. “The Expectant Brain: Adapting for Motherhood.” *Nature Reviews Neuroscience* 9 (1): 11–25.
- Bures, I., and O. Buresova. 1990. “Spatial Memory in Animals.” In *Machinery of the Mind*, edited by E. R. John, T. Harmony, L. S. Pricep, M. Váldez-Sosa, and C. Váldez-Sosa, 291–310. New York: Springer.
- Darwin, C. 1871. *The Descent of Man, and Selection in Relation to Sex*. Vol. I. London: John Murray.
- Davidsson, P. 1997. “Learning by Linear Anticipation in Multi-agent Systems.” In *Distributed Artificial Intelligence Meets Machine Learning. Learning in Multi-Agent Environments*, edited by Gerhard Weiß, 62–72. Lecture Notes in Computer Science. Berlin: Springer.
- Dubois, D. M. 2000. “Review of Incurative, Hyperincurative and Anticipatory Systems – Foundation of Anticipation in Electromagnetism.” In *Computing Anticipatory Systems CASYS’99*, edited by D. M. Dubois, 3–30. New York: AIP Proceedings.
- Feigenberg, I. M. 2014. *Nikolai Bernstein: From Reflexes to the Model of the Future*. Translated by J. Linkova. Berlin: LIT Studien der Geschichte des Sports. Translation of *Nikolai Bernstein: Ot refleksa k modeli budušego*, published also in German (2004) as *Nikolai Bernstein: Von den Reflexen zur Modellierung der Zukunft*. Moscow: Smysl.
- Gilbert, D. T., and T. D. Wilson. 2007. “Prospection: Experiencing the Future.” *Science* 317 (5843): 1351–1354.
- Jensen, R. 2006. “Behaviorism, Latent Learning, and Cognitive Maps: Needed Revisions in Introductory Psychology Textbooks.” *The Behavior Analyst*, 29 (2): 187–209.
- Kelly, G. A. 1955. *The Psychology of Personal Constructs*. New York: Norton.
- King, W. I. 1938. *The Causes of Economic Fluctuations: Possibilities of Anticipation and Control*. New York: Ronald.

- Knutson, B., A. Westdorp, and D. Hommer. 1998. "Functional Neuroanatomy of Approach and Active Avoidance Using FMRI." *NeuroImage* 7: S918. Published as Knutson, B., A. Westdorp, E. Kaiser, and D. Hommer. 2000. "FMRI Visualization of Brain Activity during a Monetary Incentive Delay Task." *NeuroImage* 12: 20–27. Accessed April 6, 2015. <http://www-psych.stanford.edu/~span/Publications/bk00ni.pdf>
- Lorenz, K. 1952. *King Solomon's Ring*. Apollo ed. New York: Thomas Y. Crowell.
- Louie, A. H. 2006. "(M,R)-Systems and their Realizations." *Axiomathes* 16 (1–2): 35–64.
- Luria, A. R. 1970. *Traumatic Aphasia*. Hague: Mouton.
- Moya, J., L. Phillips, J. Sanford, M. Wooton, A. Gregg, and S. Laurie. 2014. "A Review of Physiological and Behavioral Changes during Pregnancy and Lactation: Potential Exposure Factors and Data Gaps." *Journal of Exposure Science and Environmental Epidemiology* 24 (Sep./Oct.): 449–458.
- Nadin, M. 2010. "Anticipation and Dynamics: Rosen's Anticipation in the Perspective of Time" and "Annotated Bibliography: Anticipation." *International Journal of General Systems* (Special issue, George Klir, Introduction), 39 (1): 34–133.
- Nadin, M. 2012. "Prolegomena: What Speaks in Favor of an Inquiry into Anticipatory Processes?" In *Anticipatory Systems*. 2nd ed., edited by George Klir, xv–lx. International Book Series on Systems Science and Systems Engineering. London: Springer.
- Nadin, M. 2014a. "G-Complexity, Quantum Computation and Anticipatory Processes." *Computer Communication & Collaboration* 2 (1): 16–34.
- Nadin, M. 2014b. "Navigation Nobel: Soviet Pioneer." *Nature* 515: 37, November 6.
- Nadin M., ed. 2015. *Anticipation: Learning from the Past – Pioneering Research from the Soviet Union*. Cognitive Systems Monographs. Cham: Springer.
- Orbeli, L. A. 1923. "О механизме возникновения спинномозговых координаций" [The Sympathetic Innervation of the Skeletal Muscles]. *Bulletin of the Institute of Science of St. Petersburg* 6: 8–18.
- Pavlov, I. P. 1927. *Conditioned Reflexes: An Investigation of the Physiological Activity of the Cerebral Cortex*. Translated and edited by G. V. Anrep. London: Oxford University Press.
- Pellegrino, A. C., M. F. Gomes Villaba Peñaflo, C. Nardi, W. Bezner-Kerr, C. G. Guglielmo, J. M. Bento, and J. N. McNeil. 2013. "Weather Forecasting by Insects: Modified Sexual Behaviour in Response to Atmospheric Pressure Changes." *PLoS ONE* 8 (10): e75004. www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0075004
- Powers, W. T. 1973. *Behavior: The Control of Perception*. New York: Aldine deGruyter.
- Rose, S. 2006. *The Future of the Brain: The Promise and Perils of Tomorrow's Neuroscience*. London: Oxford University Press.
- Rose, S. 2012. *The Making of Memory: From Molecules to Mind*. New York: Random House.
- Rosen, R. 1991. *Life Itself: A Comprehensive Inquiry into the Nature, Origin, and Fabrication of Life*. New York: Columbia University Press.
- Rosen, R. 2012. *Anticipatory Systems: Philosophical, Mathematical, and Methodological Foundations*. 2nd ed. (International Federation for Systems Research International Series on Systems Science and Engineering, Vol. 1). New York: Springer.
- Seligman, M. E. P., P. Railton, R. F. Baumeister, and C. Sripada. 2013. "Navigating into the Future or Driven by the Past." *Perspectives on Psychological Science* 8 (2): 119–141.
- Shackle, G. L. S. 1938. *Expectations, Investment and Income*. Oxford: Oxford University Press.
- Sokolov, E. N. 1958. *Восприимчиве и условный рефлекс*. Moskoskogo: Izdatelstvo [Published in 1963 as *Perception and the Conditional Reflex*]. New York: Macmillan.
- Specter, M. 2014. "Drool. Ivan Pavlov's Real Quest." Review of *Ivan Pavlov: A Russian Life in Science*, by Daniel P. Todes. *The New Yorker*, November 24, 123–126. <http://www.newyorker.com/magazine/2014/11/24/drool>
- Svoboda, A. 1960. "Un modèle d'instinct de conservation." [A Model of the Self-preservation Instinct.] In *Information Processing Machine*. Collection of Papers, Vol. 7, 147–155. Prague: Czechoslovak Academy of Sciences.
- Tolman, E. C. 1948. "Cognitive Maps in Rats and Men." *Psychological Review* 55: 189–208.
- Ukhtomsky, A. A. 1923. "Доминанта как рабочий принцип нервных центров" [The Dominant as the Working Principle of the Nervous Centers]. *Russkij Fiziologeskiz Zhurnal* 6 (1–3): 31–45.
- Uznadze, D. N. 1925. *Основы экспериментальной психологии* [Principles of Experimental Psychology]. Tbilisi.
- Verstack, A., A. Acharya, H. Suzuki, S. Henderson, M. Iakhiev, C. Chiung Yu Lin, and N. Shetty. 2014. "On the Shoulders of Giants: The Growing Impact of Older Articles." arXiv: 1411.0275c1 [csDL] Accessed November 2. <http://arxiv.org/abs/1411.0275>

- Vygotsky, L. S. 1926. "Metodika refleksologicheskogo i psikhologicheskogo issledovanija." [The Methods of Reflexological and Psychological Investigation.] In *Problemy sovremennoj psikhologii*, edited by K. N. Kornilov, 26–46. Leningrad: Gosudarstvennoe Izdarel'stvo.
- Whitehead, A. N. 1929. "Process and Reality. An Essay in Cosmology." In *Gifford Lectures Delivered in the University of Edinburgh During the Session 1927–1928*, edited by D. R. Griffin and D. W. Sherburne. New York: Macmillan/Cambridge University Press.