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# Anticipation: Learning from the Past

The Russian/Soviet Contributions to the  
Science of Anticipation

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# Introduction: Commitment to Knowledge

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**Abstract** Darwin (The Descent of Man, and Selection in Relation to Sex. John Murray, London, p. 3, 1871, [1]), 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 in itself, 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 own endeavors end up undermined by a confidence that is at best illusory.

## 1 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 [2], 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, for that matter, from any other place. Albeit, in establishing an encompassing

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science of anticipation, a foundational effort that does not integrate early contributions is simply not possible, and certainly not valid. Rosen [3] placed anticipation in the framework of his attempt to define what life is. (Louie [4, p. 50] defines a “Rosen’s Trilogy” in this respect.)

My own understanding of anticipation is grounded in neuroscience. Others, from Whitehead [5] to Bennett [6], Svoboda [7], King [8], Shackleton [9], Powers [10], Kelly [11], among others, approach anticipation from the perspective of philosophy, anthropology, control theory, psychology, or economics (Nadin [12, xv–lx]). In more recent times, scientists active in artificial intelligence, neural networks, adaptive learning systems, cognitive science (Homan [13], Knutson [14], Davidson [15], Balkenius [16, 17], Dubois [18], 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 acknowledgment of contributions, preceding our efforts, from distinguished scientists—Ukhtomsky [19], Uznadze [20], Vygotsky [21], Beritashvili [22], Bernstein [23], Sokolov [24], Luria [25], and others—rarely qualify as foundational.

Doubtless, Rosen would have been as eager as I to learn more about their work, even if anticipation was sometimes incidental. Young researchers, seeking their own field of interest, will find in the Soviet/Russian attempts, frequently anchored in physiology, intriguing ideas awaiting further development. This is the ultimate motivation for initiating an international conference: *Anticipation—Learning from the Past. Early Soviet/Russian contributions to a science of anticipation*. It is the motivation for this volume (to be made available in print, as well as a publication available via Internet). We are simply building a *reference library* on the subject of anticipation.

The context of the conference fully confirms the epistemological purpose. The Hanse Wissenschaftskolleg/Hanse Institute for Advanced Study (one of the 26 such institutions in the world and, in my opinion, an exemplary establishment) entrusted me with organizing a Study Group on Anticipation Across Disciplines. Dr. Dorothe Poggel, of the Hanse Wissenschaftskolleg, and many of her colleagues were indispensable in this effort. So was Andres Kurismaa, whose efforts of the last two years (in identifying competent scholars on the subject, and further helping them make their thoughts available to a readership expecting English as the *lingua franca* of science) are impressive. If not only for identifying the concept for the conference and the effort to make it happen, but also in the laborious editing of this volume, Andres Kurismaa contributed diligently and competently. Gratitude extends to him, no matter how difficult it was to work together, and everyone who helped. A cycle of conferences dedicated to the subject of anticipation is but one concrete embodiment of this network designed to facilitate interactions among those who research anticipation. While others try, probably for noble reasons, to institutionalize anticipation, my focus is on stimulating in-depth inquiry into its condition.

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—and within this ambitious endeavor, the research that took place in the Soviet Union (since ca. 1930) deserves not only acknowledgment, however late, but especially reevaluation 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 [26]).

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, spatial navigation was defined by others cannot become a mere parenthesis in the history of science, to be ignored or forgotten. In his research, O’Keefe (one of the three Laureates) correctly references the work of Tolman [27]). 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 (Delmenhorst, Germany, September 1–3, 2014), Merab Tsagareli, 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 Tsagareli 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 for making progress in the foundation of the study of anticipation. References pertinent to the subject (Beritashvili [22, 28–33], Bures and Buresova [34], Jensen [35]) 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.

Let me repeat: this volume is intended as a reference publication. Therefore, it was not conceived as mere proceedings to a conference. Some papers presented at the conference—meritorious in their own way—were left out when the authors ignored the goal of this volume or they did not have the knowledge pertinent to anticipation in order to highlight the contributions of those about whom they wrote. Moreover, when necessary I encouraged distinguished authors who could not be present to fill in the gaps: John-Paul Ito, Lucia Pavlova, Valentina Ilyukhina, Alexander Kazansky, Vladimir Tsygankov, Dali Parjanadze, Ketevan Makashvili, Fabian Labra-Spröhnle. To place contributions such as those of the scientists discussed in this book in the perspective of their relevance to a science of anticipation is a challenging task. We look back 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 escape us. In a few cases

(Beritashvili, Bernstein, Ukhtomsky), historic accounts were contributed by those who themselves experienced the events in the Soviet Union. Dr. Tsagareli was already mentioned. Dr. Iosif Feigenberg also deserves our gratitude. He is the author of a detailed biography of Bernstein [36]; the English edition [37] was released at the conference, with a reception to mark the event. Feigenberg is not only a witness, but also a contributor to the knowledge of anticipation. He advanced the probabilistic prognosis model—in which anticipation might come short, given the focus on probability and the lack of a possibilistic perspective. But as a contemporary of Bernstein (who made specific reference to his idea) and as a contemporary of ours, Feigenberg remains passionate about acknowledging the role that the future plays in anticipatory processes. It is impossible not to associate his contributions to those reported within the conference by Latash (Bernstein’s “Desired Future” and Physics of Human Movement, in this volume).

## 2 A Broader View: Anticipation Is Definitory of Life

These introductory lines will not follow the tradition of summarizing particular contributions appearing in this book. Each author prepared an abstract, thus there is no reason to echo their words. I prefer to focus on their genuine dedication to a competent approach that will ultimately result in a science of anticipation. With this goal in mind, I will take the opportunity to suggest a bridge between their findings and views 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.* 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. Behaviors 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 living. 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 behavior to weather patterns (Pellegrino et al. [38]). 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 behavior, 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 anecdotal, some very precise, of reproductive processes have been advanced in almost all cultures. Spectacular progress in genetics and molecular biology, as well as in neurophysiology, provided extremely detailed descriptions of the anticipation implicit in reproduction (for example Brunton and Russell [39], Moya et al. [40]). Anatomical, physiological, emotional, and other changes (such as hormonal) are associated with fertilization and early embryo formation. 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 way.) Women who have gone through pregnancy reported on 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, anemia, etc. The skin darkens, 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 of, not in reaction to, the formation, growth, and development of the fetus. 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 [41]). The entire process of reproduction has an internal coherence that integrates pre-fecundation, fecundation, pregnancy, parturition, lactation, maternal behavior. 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 behavior 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 role different from that in the ewe that has given birth. This is the classic example of how bonding takes place. Lorenz’s [42] work 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 volume. 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, or *prospection* (a more recent concoction of dubious psychological elaboration, [43, 44]).

The fact that we do not share in the understanding of the concept of anticipation goes back to the view of life that has dominated ever since vitalism—which maintained that a clear-cut distinction between the living and the non-living is not possible—was debunked. It is not my desire to associate with those who are labeled “neo-vitalists” (such as Driesch [45], Hartman [46]). But one cannot ignore that Russian scientists (Bekhterev [47], Korzsinsky [48], Borodin [49], Danilevsky [50], among others) were indeed active in articulating hypotheses regarding the distinct nature of what they called “living substance.” Some of these thoughts affected the authors who can be considered as early researchers of anticipation. Arthur Eddington, John Eccles, Henri Bergson, and their followers were not ignored by the Soviet scientists whose work preoccupied the international conference dedicated to them. For a larger image of where this work fits in the science and philosophy of the time, I would like to make reference to a web publication (Nadin [51]) that offers the narration of anticipation focused on publications for the last 120 years. It integrates Palagyi’s work on consciousness (1908), Beritashvili’s initial research in physiology (1919), Ukhtomsky’s “dominant” as the principle of nerve centers (1923), Bernstein’s new perspectives on reflexes (1924), Uznadze’s contributions to experimental psychology (1925), Whitehead’s “future possibilities” (1929), Anokhin’s functional systems (1935), Shackle’s definition of expectations (1938), King’s focus on anticipation related to economic fluctuations (1938), Bartlett’s “receptive-effective” distinction (1951), among others.

I do not suggest here any associations among their respective ideas. Rather, I suggest the *Zeitgeist* that explains Kelly’s “psychology of personal constructs” (1955), Sokolov and Krushinsky’s work on the concept of reflex (1958 and 1959), Leontev’s views of mind development (1959), Svoboda’s “Self-preservation instinct” (1960), Gelfand’s control for complex systems (1962), Feigenberg’s focus on the mind as probabilistic prognosis (1963), Galperin’s focus on learning (1967), Volpert’s concentration on sensory motoric aspects (1969), Vygotsky and Luria’s “tool and symbol” in child development (1970), Power’s “control of perception” (1973), Burger’s causality and anticipation (1975), Bennett’s anticipation as basis for adaptation (1976), Shirker’s focus on neurophysiological aspects (1978), my own early work on anticipation as a characteristic of artistic activities (1978), Hacker’s focus on engineering aspects, Feynman’s interrogations on the role of future states in computation (1982), Rotenberg, Arshavsky and Simonov’s issues of

adaptability (1985), Rosen’s philosophical and mathematical foundations (1985), Pavlova and Romanenko’s work on the brain (1988). Of course, in the rather broad “geography” of contributions to a possible foundation for anticipation, Libet’s experiments [52] play a significant role, and are part of the timeline. All these form a work in progress that will benefit from input from the larger community of researchers in anticipation.

In a rather provocative study, Verstack et al. [53] produce data on “the growing impact of older articles.” Of course, in considering the Soviet School, “older” does not mean 15 years, but rather 80 to 40 years ago, which Scholar Metrics (used by the Verstack “group” of Google data-mining) still ignores. On the shoulders of the “giants” introduced in this volume, 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. Anticipation is no longer reducible to physics, or to psychology, or to physiology, or to any other field of knowledge. It has ascertained its own domain of knowledge. The conference, together with the volume arising from it, is yet another instance in this process.

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