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## Guest Editor's Introduction

### Nikolai Bernstein: The Physiology of Activeness and the Psychology of Action

The year 1966 occupies a special place in the history of Russian psychology in the twentieth century. It is, in a certain sense, a signal year. It was in 1966 that the psychology faculty of Moscow State University began its work. In the same year the Eighteenth International Psychology Congress was held in Moscow, with outstanding psychologists such as J. Piaget and K. Pribram taking part.

This year was marked by one other event requiring special mention. I have in my hands the book *Cybernetic Aspects of the Integral Activity of the Brain: Materials of the Eighteenth International Psychology Congress* [Kiberneticheskie aspekty integral'noi deiatel'nosti mozga: materialy XVIII Mezhdunarodnogo psikhologicheskogo kongressa] (Moscow, 1966). This book contains a paper by N.A. Bernstein: "The Next Tasks of Neurophysiology in Light of the Contemporary Theory of Biological Activeness" [Ocherednye zadachi neurofiziologii v svete sovremennoi teorii biologicheskoi aktivnosti]. Bernstein did not attend the congress itself because of his untimely demise in January 1966.

Forty years have passed, but interest in the scientific legacy of the outstanding Russian scientist N.A. Bernstein has not only not died away but, on the contrary, grows greater and greater. Psychologists rightly regard him precisely as a psychologist. It suffices to recall that as early as 1927 he participated, together with L.S. Vygotsky and A.R. Luria, in the creation of the *Practice Workbook in Experimental Psychology*

(Artemov et al., 1927). In addition, both Luria and A.N. Leontiev referred repeatedly to Bernstein's research.<sup>1</sup> Specialists in cybernetics consider him one of their own, and not without grounds. (Suffice it to say that Bernstein substantiates in his works the principle of feedback in biological organisms.) So, incidentally, do mathematicians (for example, Academician I.M. Gelfand, with whom Bernstein collaborated fruitfully in the last years of his life). Bernstein's ideas have significantly enriched the clinical practice of neuropsychology and medicine, not to mention the physiology and psychophysiology of activeness and the biomechanics of human movements.

Today his theory of levels of the construction of movements is widely known both in Russia and abroad. His main works have been published and are accessible to researchers.<sup>2</sup> And, at the same time, one extraordinarily important circumstance must be mentioned.

The point is that the significance of Bernstein's works goes beyond the bounds of physiology; they are of fundamental importance for *psychology*. It is precisely for this reason that we have undertaken to publish works of Bernstein in this issue of the *Journal of Russian and East European Psychology*. In this connection, in this brief introductory commentary, I would like to dwell on certain fundamental positions in Bernstein's research that bear the most direct relation to psychology.

If we try to present the logic of Bernstein's train of thought in the most compressed and concentrated form, then it can be expressed in two short formulas:

- from reactivity to activeness;
- from mechanism to organism.

Developing the line of argument begun in the works of the outstanding Russian physiologist A.A. Ukhtomskii, Bernstein looks at the organism not as a passive, reactive system that merely responds to external stimuli and adapts to environmental conditions (as the thinkers of the period of "classical" mechanism in physiology regarded it), but as an active system created in the process of evolution that strives toward a goal.

As a counterweight to study of the organism in states of rest, the new research trend, Bernstein thought, should emphasize study of the active behavior of the organism. In other words, the process of life is not "equilibration with the environment" but the *conquest* of this environment. It is aimed not at maintenance of status but at movement in pursuit of the species program of development and self-provision. The living organism is, therefore, an anti-entropic system.

Thus, the motor behavior of man does not take shape from reflexes as from “blocks.” The movement (act) of an organism is not *reaction* but *action*, aimed at transformation in a situation in accordance with a set task. If Pavlov created a physiological theory of the elements of acts, then Bernstein created a physiology of *activeness* that extends to the highest forms of mental activity. If for Pavlov a reflex is an element of an act, then for Bernstein a reflex is an elementary act.

It was precisely this departure from the principles of reactivity and mechanism traditional to classical physiology and his resort to the new principles of *activeness* and *organism* that enabled Bernstein to make a series of discoveries of fundamental importance for psychology. These were, first of all, the idea of sensory adjustment of the motor act and the concept of the “motor task” and of the image of the required future.

These two fundamentally important ideas are closely interconnected and, in a certain sense, supplement one another. However, for the sake of simplicity of presentation I shall dwell on each of them separately.

### **From the principle of sensory adjustments to the idea of biological feedback**

Prior to Bernstein’s work in physiology, it was thought that the motor act is organized in the following fashion: at the stage of learning a movement, its program is formed and recorded in the motor centers; then as a result of the action of some kind of stimulus this program is activated, motor command impulses go out to the muscles, and the movement is effected. Thus, in its most general form the mechanism of a movement was represented by a diagram of a *reflex arc*: stimulus–process of its central processing (activation of programs)–motor reaction.

Bernstein arrived at the conclusion that the complex motor acts that are called upon to solve some kind of task or achieve some kind of result cannot be constructed in this way. The main reason is that the result of any complex movement depends not only on control signals proper, but also on a whole series of additional factors that have a property in common: they all introduce deviations from the planned course of the movement while not being themselves subject to calculation in advance. As a result, the final goal of the motion can be attained only if corrections or adjustments are constantly made to it. Thus, Bernstein proposed a quite new principle of the control of movements; he called it the principle of sensory adjustments, having in mind adjustments made to motor impulses

on the basis of sensory information about the course of fulfillment of the movement.

With the introduction into psychophysiology of the concept of sensory adjustments, the classical conception of an open-ended *reflex arc* was replaced by the conception of a closed cycle of the regulation of movements, of a *reflex ring*—in fact, that is, by the conception of biological feedback.

The importance of this new principle for psychology consists in the fact that Bernstein regarded sensory adjustment as a constitutive component of the motor act itself, a component comparable in complexity with the *intellectual* process.

And this, in its turn, led to the study of movements becoming a means for acquiring knowledge of the laws of the working of the brain. Bernstein often used to say that a scientist wishing to understand how the brain works will hardly find a more rewarding object of investigation than the control of movements. In order to accomplish one or another movement, the brain not only sends a specific “command” to the muscles, but also receives signals from the peripheral sense organs concerning results achieved and on their basis gives new, adjusting “commands.” Thus, there occurs a process of the construction of movements in which the brain and the peripheral nervous system are linked together not only by one-way connections but also by feedback. In this way Bernstein proposed at the level of physiology and psychophysiology his own solution to the eternal *problem of psychology*, the problem of “brain and mind.” The brain is an “organ of mind” only to the degree that it is an organ participating in the construction of movements and acts, which generate the mental image as such. It is the evolution of the organism, the ontogenesis and phylogenesis of living movement and action that create the developed brain as their organ. From the evolutionary-historical point of view, both the developed brain and the developed consciousness have a common “root”—the living movement and goal-directed action effected by the organism as it actively overcomes its environment.

### **The motor task and the image of the required future**

The introduction of the principle of sensory adjustments compelled Bernstein to introduce another new concept into psychophysiology. This was the concept of the “model of the required future,” which establishes

the necessity for the presence in the brain in some “coded” form of a presentiment of the required final result of a movement.

Any living movement, according to Bernstein, is a process of solution of some motor task. If the cause of a reactive act is the irritant that has set it off, then the cause of an active act is a psychophysiological image of what does not yet exist, of what still has to come about—that is, some kind of model (image) of the required future.

“We may assert,” he wrote in this regard, “that at the moment when a movement begins, the entire aggregate of engrams needed to bring this movement to completion is already present in the central nervous system. The existence of such engrams is proved by the very fact of the existence of motor skills and of movements that have become automatic” (Bernstein, 1990, p. 281).

This idea of Bernstein’s is quite well known, and there would be no point in referring to it were it not for one circumstance to which I must draw the attention of *psychologists*. This consists in the fact that in speaking of the motor task as a concrete form of the image of the required future Bernstein begins to speak also of the “motor image”—that is, the image or, more precisely, the pre-image of the *movement*.

He wrote:

We have, by all accounts, two connected processes. One of them is *probabilistic forecasting* in accordance with the perceived current situation. . . . Alongside this probabilistic extrapolation of the course of surrounding events . . . there is effected the process of programming of the act that must lead to the realization of the required future. (Ibid., p. 438)

But, after all, both the image of the required future and the image of the movement are none other than fully fledged mental images, the same mental reality that always slips away from any attempt at its direct examination.

“Image of the required future,” “probabilistic forecasting,” “motor task,” “sense of movement in the system of an act,” “image of an act”—even an enumeration of the concepts used by Bernstein shows that they belong not only to physiology but also to psychology. Bernstein himself understood this.

Is it permissible to consider that the goal of an act—something that must be accomplished only after this act in future time—may be the cause of the occurrence of this act? . . . And is it in general correct to extrapolate the concept of goal beyond the limits of psychology—the

sole field in which it can be formulated with full intelligibility? (Ibid., pp. 453–54)

To this question he gives a quite definite answer:

The goal . . . conditions the processes that have to be united in the concept of goal-directedness. The latter incorporates the entire motivation of the struggle of the organism for the attainment of the goal and leads to the development and strengthening of goal-conforming mechanisms of its realization. And the entire dynamic of goal-directed struggle by means of goal-conforming mechanisms is a complex that is brought together most correctly by the term “activeness.” (Ibid., pp. 454–55)

And the point is not only that in describing the movements of the living organism Bernstein also used such concepts as goal, goal-directedness, attainment of the goal, act, motivation, and activeness.

Strictly speaking, in the dynamic structure of complex living movement and action the boundary between the physiological and the psychological is erased. More precisely, this boundary becomes mobile. A conscious, volitional, mediated act, as it coagulates and becomes automatic, turns into a nonvolitional, direct, reflex act. And conversely, a “reflex” movement, incorporated into a complex whole as its subordinate part, may again acquire independent significance, enter into the sphere of consciousness, and become a volitional act. And the problem of the transformation of a volitional, mediated act into a nonvolitional, direct act and vice versa is one of the most complex and least studied in contemporary psychology, or at least in the psychological theory of activity.

There may, however, arise the question: but are there really no reactive processes, that is, movements constructed on the model of a reaction?

Bernstein has an answer to this question. Let us order all the movements of an animal or human being in a series along some imagined axis in accordance with the degree to which any movement is determined by an external stimulus. Then at one end of this series we shall find unconditioned reflexes like the sneezing, blinking, and knee-jerk reflexes, and also conditioned reflexes formed during the individual’s life, such as salivation in the dog. These movements, or acts, are, indeed, set off by a stimulus and are determined by its content.

Next in this series come movements that are also set off by an external stimulus, but are no longer so rigidly connected with it in terms of content. For example, a person may react to the infliction of a physical

blow in a variety of ways: he may run away, or he may strike back, and so on.

In these kinds of situations a stimulus leads not to a movement or act, but rather to the taking of a decision regarding an act. In these cases it fulfills the role of a “trigger.” It activates one of a number of possible alternative programs. Acts of this type occupy an intermediate position in our imagined series.

And, finally, at the other extreme pole we shall find those acts for which, as Bernstein writes, both the triggering initiative and the content—that is, program—are given from within the system of the act itself. These are the acts that are defined in psychology as volitional acts.

Thus, reactions are only a special case of activeness. Just as rest is a special case of movement, movement with zero velocity, so are unconditioned reflex reactions acts with zero degree of activeness, and they comprise a very small proportion of all acts of life activity.

With this it would be possible to conclude our discussion of Bernstein’s contribution to psychology. But there is another aspect that requires separate treatment.

### **The mental image: Reflection or outcome?**

In the history of psychology there have always been two fundamentally different tendencies. The first, which goes back to Hume and Locke, proceeds in all its theoretical constructions from the principle of reflection, regarding the mental image as a result of the reflection in consciousness of objects and phenomena of the external world. This tendency is usually designated as the tendency of Descartes, for it is in the works of this thinker that it found its most consistent expression.

The second tendency, which goes back to Leibnitz and Kant, is based on the principle of generation. The images of objects and phenomena of the external world are generated, constructed, created. Let us recall that Kant called the capability of human sensibility to transform the externally objective presence that “irritates” it into a subjective image, the capability to construct images “the creative capacity of the soul.” In *psychology* this tendency is designated as the tendency of Spinoza, who proposed a solution to the psychophysical problem—true, only at a general philosophical level.

The first of these tendencies in theoretical thought obtained powerful experimental substantiation in physiology thanks to the theory of re-

flexes. The second tendency, that of Spinoza, was unable to boast the same kind of confirmation.

At the same time, both tendencies came up against the same task, which appeared insoluble for them both. How does the image of an object arise in three-dimensional space, when on the retina of the eye its representation is always two-dimensional and cannot be otherwise by definition, by the nature of things?

I think that Bernstein's research has brought clarity to this apparently insoluble problem.

It was precisely to this circumstance that Bernstein's pupil I.M. Feigenberg first drew attention:

The general principles of the control of movements led Bernstein to a conception of the hierarchical structure of complex control systems. Bernstein demonstrated the defining role of afference in the construction of movements. . . . It was shown that out of afference grows the subjective space, out of the space the object, and out of the object the most generalized objective concepts. Out of efference grows subjective time, out of time meaning-oriented action, and out of the latter at the highest levels behavior, and, finally, the supreme synthesis of behavior—the personality or subject. Bernstein analyzes the object-related level of movements, at which it is not the purely physical spatial image that plays the leading role, but the meaning-oriented image in which the significance of the object is embodied. (Feigenberg, 2004, pp. 128–29)

In other words, Bernstein showed that the image of an object is none other than a coagulated, compressed image of movement that follows the form of this object. This fully corresponds to Spinoza's idea of the thinking body! And this is not surprising, because *only the psychophysiology of activeness*, the founder of which was Nikolai Aleksandrovich Bernstein, can give an answer to the question of the preconditions of the birth of the human mind and consciousness.

## Notes

1. It is interesting in this connection to mention that *The Encyclopedic Dictionary of Psychology* (Cambridge: MIT Press, 1983) notes the enormous importance of Bernstein's ideas precisely for psychology. The latest Russian edition of Bernstein's works came out in the series "Psychologists of Russia" [Psikhologi Rossii] (N.A. Bernshtein [Bernstein], *Biomekhanika i fiziologiya dvizhenii. Izbrannye psikhologicheskie trudy* [Moscow-Voronezh 2004]).

2. N.A. Bernstein, *The Coordination and Regulation of Movements* (New York: Pergamon-Press, 1967); N.A. Bernstein, "Methods for Developing Physiology as



Related to the Problems of Cybernetics,” in *A Handbook of Contemporary Soviet Psychology*, ed. M. Cole and I. Maltzman (New York: Basic Books, 1969); N.A. Bernstein, *Dexterity and Its Development*, ed. M.L. Latash and M.T. Turvey (Mahwah, NJ: Lawrence Erlbaum, 1996).

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