

Ivan P. Pavlov

An Overview of His Life and Psychological Work

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Ivan P. Pavlov (1849–1936), while studying in the 1860s at the Riazan' Ecclesiastic Seminary, was profoundly influenced by Russian translations of Western natural science literature, especially that with strong Darwinian overtones, and he abandoned a career in the church. He became a professor of physiology in 1895 at the Imperial Military–Medical Academy in St. Petersburg, where he did research on the digestive process (for which he was awarded the Nobel Prize in 1904). Starting in 1901 and for the next 35 years, Pavlov, using primarily the salivary reflex conditioning method, systematically accumulated experimental results that were sufficient to formulate the theory of higher nervous activity, which described the functions of the brain in complex organisms' adjustment to a changing external environment. Essentially a psychological theory, it encompassed innately determined instincts, temperament types, the acquisition of knowledge and adaptive patterns in terms of a dynamic stereotype, the nature of language, the characteristics of old age, and the etiology of neuroses and psychoses. Pavlov's international reputation as a scientist most likely enabled him to be critical of the Bolshevik regime and to publicly defend human rights and academic freedom in the Soviet Union.

In 1904, the faculty of the Royal Carolinian Medical–Surgical Institute awarded Ivan P. Pavlov (1849–1936) the Nobel Prize in physiology and medicine (Ångström, Pettersson, Mörner, & Virsen, 1907). The award recognized Pavlov's scientific work on digestive processes, although at that time Pavlov (1903/1951c) was interested in brain processes of complex animals. Although he continued to consider himself a physiologist, his research was actually a psychological endeavor.

Pavlov's Heritage and Youth

Pavlov descended from a Russian serf named Pavel, who lived on a landowner's estate near the historic town of Riazan'. The Pavlov family was emancipated when Pavlov's great-grandfather became a sexton in the Russian Orthodox Church. Subsequently, the Pavlov family was socially mobile; each successive generation moved higher in the church hierarchy. Pavlov's father, Petr, was an ordained priest and was known for his erudition. Pavlov's mother, Varvara, herself a priest's daughter, was bright but illiterate (Pavlov, 1952b). After the death of her third

child, she suffered a "nervous disorder" (Anokhin, 1949). It is possible that Pavlov's lifelong interest in psychiatry was related to his mother's condition.

Traditionally, priests' sons were slated for the church (Anokhin, 1949), and so, in the 1860s, Pavlov studied for the priesthood at the Riazan' Ecclesiastical Seminary. Years later, Pavlov (1952a) reminisced that he received a good education that, in Russian seminaries of that period, emphasized the classics and theology (Titlinov, 1909). Then, in the 1860s, the cultural environment within the Russian empire changed dramatically. The regime of Tsar Alexander II permitted the publication of Western scientific works in the Russian language. In the Riazan' Public Library, Pavlov read popular renditions of physiology and Darwin's theory of evolution (as cited in Windholz, 1991). Years later, Pavlov (1952a) reminisced that after reading these works, he became interested in natural science. Rejecting a career in the church, he matriculated in 1870 at the Faculty of the Physical–Mathematical Sciences of the University of St. Petersburg. In 1883, Pavlov was awarded an MD degree by the Imperial Military–Medical Academy (Gureeva & Chebysheva, 1969).

Somewhat late in life (in 1890), the 41-year-old Pavlov was appointed professor of pharmacology and then, in 1895, professor of physiology at the Imperial Military–Medical Academy in St. Petersburg (Gureeva & Chebysheva, 1969). Beginning in 1901, Pavlov shifted his interest from the digestive processes to the investigation of the functions of the brain, by means of the salivary reflex conditioning method.

Salivary Reflex Conditioning in Pavlov's Laboratory

Pavlov directed several physiological laboratories of which the most prominent was the Imperial Institute of Experimental Medicine in St. Petersburg. From 1897 to 1936, at least 146 Pavlovians—graduate students and a few permanent coworkers—investigated animals' brain functions (Windholz, 1990). The Pavlovians usually ex-

I made the translations from Russian sources.

I wish to thank J. R. Kuppers, P. A. Lamal, and D. P. Todes for their suggestions and editorial assistance and librarians A. D. Cobb and B. J. Lisenby for their help in providing source materials.

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perimented at Pavlov's behest, for he rarely experimented himself, preferring to supervise each experimenter's work. Breach of the specified experimental procedures evoked Pavlov's anger. Although the memoirs of Pavlovians express admiration for Pavlov, several of them (e.g., W. Horsley Gantt [1973] and L. A. Orbeli [1966]) mentioned his emotional outbursts.

Pavlov was profoundly influenced by Darwin's concept of the struggle for existence and its functionalistic implications. In the 1890s, he hypothesized that the upper tract of animals' digestive system responded functionally to specific foods, namely, a small salivary secretion to moist foods, such as meat, and a larger salivary secretion to dry foods, such as bread. Pavlov's student, S. G. Vul'fson (1898) tested this hypothesis in 1897 at the Imperial Institute of Experimental Medicine. In addition to finding experimental support for Pavlov's hypothesis, Vul'fson found serendipitously that after eating the moist and dry foods, dogs that were "teased" from afar by these foods responded with a corresponding but diminished salivary secretion. Salivation to stimuli presented at a distance was anomalous because, in view of the Cartesian conceptualization of reflexive action, an immediate contact between environmental agents and the organism's sensory receptors was required. Pavlov realized that although salivation was of minor physiological importance in the animal's adjustment to the environment, it was, nevertheless, an observable response to stimuli (Pavlov, 1903/1951c) that revealed the brain's neural processes. The use of precise and sensitive salivary reflex conditioning as a method in the study of the normal animal's cortical processes was of revolutionary significance considering that the previously used method of exploring cortical functions was extirpation performed on a traumatized animal (Pavlov, 1912/1951j).

Pavlov's Theory of Higher Nervous Activity

From 1897 to 1936, at least 532 papers involving salivary reflex conditioning were produced under Pavlov's direction (Windholz, 1990). On the basis of these findings, Pavlov formulated the theory of higher nervous activity (Russian translation: vysshaiia nervnaia deiatel'nost'), which described the function of the brain of complex organisms in interaction with the ever-changing, external, mainly social environment. In contrast, the lower nervous activity (Russian translation: nizshaia nervnaia deiatel'nost') integrated and regulated the organism's diverse parts (Pavlov, 1932/1951e).

Pavlov claimed that his theory was purely physiological (Wolfe, 1947), but actually it was a psychological theory conceptualized on three levels: (a) the behavioral level, which considered the organism's overt interaction with the external environment; (b) the physiological level, which involved a complex interplay of the brain's neural excitatory and inhibitory processes that irradiated and then concentrated in the foci of original irradiation; and (c) the conscious level that, although identical with physi-

ological processes, was experienced subjectively (Pavlov, 1933/1951i).

Pavlov's Methods

Starting in 1906, Vul'fson's (1898) method of conditioning was named *natural conditioned reflexes* (Russian translation: natural'nye uslovnye refleksy) in contradistinction to V. N. Boldyrev's (1905) *artificial conditioned reflexes* (Russian translation: iskusstvennye uslovnye refleksy). To the Pavlovians, Vul'fson's conditioning paradigm was methodologically constrained because the unconditioned stimuli (UCSs; e.g., bread in mouth) and the conditioned stimuli (CSs; e.g., seeing bread) were similar, so that the use of the latter as an independent variable in complex experiments was limited. Boldyrev, however, found that any originally indifferent stimulus became a CS that evoked salivation when closely followed by the UCS, such as food. Boldyrev's salivary reflex conditioning paradigm was versatile because any appreciable stimulus from virtually any sensory modality might be used as an independent variable in Pavlovian salivary reflex conditioning experiments.

In general, Pavlov (1934/1951i) believed that the organism's survival depended on the unconditioned responses to the continuously changing environment. Survival is enhanced by the conditioned acquisition and extinction of responses to that environment. It follows that adjustment to the environment could be best explored by the salivary reflex conditioning method because continuous acquisitions and extinctions of responses to the extralaboratory environment were analogous to experimental findings that conditioned reflexes were relatively easily acquired and as easily extinguished (Windholz, 1987).

In the last six years of Pavlov's life, Pavlovians performed a number of experiments in the realm of abnormal psychology. Pavlov supplemented this research with clinical observation; under the guidance of psychiatrists, he studied human neuroses and psychoses at two Leningrad clinics. In that setting, his method consisted of interviewing patients and observing their behavior (Bykov, 1954, 1955, 1957).

In the Pavlovian salivary reflex conditioning experiments, the subjects were restrained dogs, but in the 1930s, Pavlov's laboratory obtained two chimpanzees. Pavlov (n.d./1975), critical of Wolfgang Köhler's (1921) insightful explanation of problem solving, successfully replicated Köhler's experiment in which an ape had to reach a suspended bait by building a tower that consisted of different sized boxes. By observing the ape's behavior, Pavlov noted that it took several months for it to solve this problem; it had to move the boxes directly under the bait, arrange the boxes in vertical order with the larger below the smaller, and test the construction's stability by climbing on the uppermost box and moving back and forth. Pavlov called this process the *chaotic method* (Russian translation: khaoticheskiĭ metod), which he thought to be identical to the Thorndikian trial and error method (Pavlov, n.d./1975).

Instincts and Temperament Types

The organism's fundamental responses to the external and internal environments are innately determined movements—the *unconditioned reflexes*, which, if complex, Pavlov (1932/1951e) called *instincts* (Russian translation: instinkty). Pavlov identified several instincts, of which two were crucial to individuals' ontogenetic survival: the *alimentary instinct*, which prompted the organism's food-seeking and eating behavior, and the *defensive instinct*, which was aimed at avoiding noxious or harmful stimuli. The sexual instinct enabled the phylogenetic continuity of the species (Pavlov, 1930/1951f).

When Pavlov (1935/1951g) observed the overall behaviors of animals in the laboratory, he noted considerable individual differences (i.e., temperaments) that consisted of three parameter characteristics of the nervous system: (a) the intensity or strength level of excitation and inhibition, (b) the interrelation between excitation and inhibition, and (c) the rapidity of the spread of these processes. Although permutations of these parameters could produce many temperament types, Pavlov observed only four, which corresponded to Hippocrates's humors: choleric, melancholic, sanguine, and phlegmatic (Pavlov, 1934/1951l).

First and Second Signal Systems

In Pavlov's (1927/1951d) theory, the organism's unconditioned reflexes, which are generated in the subcortical regions of the brain, are evoked by direct or immediate contact with the external environment. In contrast, the conditioned reflexes, which are established in the cortical regions of the brain, are evoked by signals emanating from the external environment and, therefore, constitute the first signal system (Russian translation: pervaiā signal'naia sistema). Because the environment is constantly changing, the first signal system corrects the organism's adjustment by acquisition and extinction of reactions to signals coming from the environment (Pavlov, 1932/1951e). However, because the human environment is mostly social, adjustment can be enhanced by language or by the second signal system (Russian translation: vtoraiā signal'naia sistema) that, in Pavlov's (1932/1951e) words is as follows:

Speech, especially the kinesthetic stimulations that come to the cortex from speech organs, are the second signals, the signals of signals. These constitute an abstraction of reality and allow generalization that constitutes our own, especially human, higher thought. (pp. 232–233)

According to Pavlov (1935/1951k), humans, depending on the dominance of the first or the second signal system, fall into two major types. Individuals dominated by the first signal system constitute the visualizing, *artistic type*, whereas individuals dominated by the second signal system constitute the verbal, *thoughtful type*. As we shall see, each type is prone to a different neurosis.

Normal Behavior: Activity and Inactivity

According to Pavlov (1934/1951l), complex behavior can be acquired or modified by the organism's interaction

with the environment. In the 1930s, Pavlov (1932/1951a) asserted that such behavioral acts are formed by numerous stimuli that impinge on the senses and then enter the cerebral cortex where "these meet, collide, interact, and, ultimately, are systematized, balanced, and so to say, end as dynamic stereotype" (p. 240). The *dynamic stereotype* (Russian translation: dinamicheskii stereotip) was established when each stimulus followed by a UCS impinges on the cortex in close temporal order. For example, when stimuli of different modalities, such as sound or light, are systematically reinforced by being closely followed by a UCS according to some schedule of reinforcement, these stimuli ultimately form on the neural level an integrated, Gestalt-like stimulus set. The experimental test of a dynamic stereotype is as follows: Does any one constituent stimulus belonging to the set evoke all the other responses of that constituent set? If that single stimulus evokes all the other responses to the constituent stimuli, then the dynamic stereotype is established. If it is established, then in daily life, an individual's response to an environmental situation consists of all behaviors belonging to the dynamic stereotype. Therefore, a well-established habit is a dynamic stereotype. Moreover, the individual's adjustment is enhanced because a dynamic stereotype generalizes from one environmental situation to another, differentiates between several environmental situations, and becomes extinguished if its function is not reinforced by the environmental situation (Pavlov, 1932/1951a; Windholz, 1996).

The spread of cortical excitation instigates and maintains behavior, whereas the spread of cortical inhibition slows down, or restrains, behavior. Normal, everyday behavior is based on a judicious interplay of excitation and inhibition, that is, of active and restrained behavior according to environmental contingencies. Unlike everyday activity, normal sleep results from an extensive irradiation of inhibition over large parts of the central nervous system (Pavlov, 1932/1951e).

Learning by Association: Conditioning and Trial and Error

As mentioned before, the process of learning, regardless whether it constitutes daily-life adjustment, the acquisition of knowledge, or scientific discovery, is based on association. Thus, during the November 13, 1935, "Wednesday Seminar"—a weekly meeting of Pavlovians—Pavlov stressed the following:

You see, association—is a generic concept, that is, a union of that which previously was separate, an amalgamation, generalization of two points in a functional relationship, [and] their merger into one association. (as cited in Orbeli, 1949, p. 262)

The formation of associations occurs under at least two conditions: first, in terms of adjustment (Russian translation: prispособlenie) that is established paradigmatically through classical conditioning. Adjustment is of biological significance to the animal; the actual environmental events are signaled by acquired temporary signals, that is, CSs. Second, the acquisition of knowl-

edge (Russian translation: obuchenie) in which two or more phenomena are intrinsically connected in reality, regardless of whether they are acquired in daily life or the scientists's laboratory, is accomplished by means of trial and error behavior (Windholz, 1992).

Spontaneous or So-Called "Voluntary" Behavior

In the late 1920s, two Warsaw, Poland, medical students, Jerzy Konorski and Stefan Miller, informed Pavlov of their motor conditioning experiments. In one of their experiments, an indifferent stimulus (light) preceded the passive lifting of a dog's foreleg that was followed by feeding. Subsequent application of that stimulus evoked a spontaneous raising of that foreleg (Windholz & Wyrwicka, 1996). These experiments sparked Pavlov's interest in the conditioning of motor movements and in the nature of the spontaneous, or so-called voluntary movements (Russian translation: proizvol'nye dvizheniia). Pavlov held that voluntary activity per se is an illusion because all activities are determined, and he proposed that the belief in voluntary activity is due to the unique attributes of the motor analyzer. Unlike other analyzers (i.e., sensory mechanisms, such as the visual or auditory system), the motor analyzer has on the cortical level both afferent (receptor) cells and efferent (motor movement) cells. A stimulus of any sensory modality can be connected by conditioning with the afferent cells of the motor analyzer. Because of previously established connections (mostly acquired during the individual's childhood) between the motor analyzer's afferent cells and its efferent cells, the application of a CS of any sensory modality evokes behavior that is considered by the human to be voluntary (Windholz, 1997).

Abnormal Behavior: Neuroses and Psychoses

In 1916, one of Pavlov's students, N. R. Shenger-Krestovnikova (1921), performed experiments on visual discrimination in dogs that resulted, unexpectedly, in disorganized behavior. In the 1920s, Pavlovians who were aware of Shenger-Krestovnikova's work began to explore *experimental neuroses*, that is, behaviors that deviated from the standard behavior established in laboratory experiments with animal subjects. Then, during the 1930s, Pavlov studied human neuroses and psychoses at the Neurotic and Psychiatric Clinics in Leningrad. Pavlov (1934/1951b) linked both endeavors, concluding that he had sufficient knowledge to explain abnormal behavior within his theory of higher nervous activity.

In Pavlov's (1932/1951h) conceptualization, *neurosis* referred to the organism's "chronic disturbances of the higher nervous activity" (p. 149). Animal experiments showed that neuroses occurred when the organism's interaction with the environment was disturbed by powerful conditioned environmental stimuli that overwhelmed the excitatory processes, when environmental demands overwhelmed the inhibitory processes, or when a conflict occurred between irradiated excitation and inhibition (Pavlov, 1934/1951b). Whereas the normal dynamic stereotype was based on a balance of excitation

and inhibition, difficult environmental conditions disturbed and exhausted these processes so that behavior became less effective and adjustive (Pavlov, 1934/1951i). Certain temperament types were prone to neuroses, especially the "weak" type, which was either poorly conditioned or behaved chaotically. Specifically, *psychasthenic neuroses* occurred in weak individuals of the thoughtful type, whereas *hysterical neuroses* occurred in weak individuals of the artistic type (Pavlov, 1935/1951k).

Pavlov studied human psychoses at the Psychiatric Clinic in Leningrad (Bykov, 1954, 1955, 1957). In 1935, Pavlov (1935/1951g) explained the etiology of schizophrenia. It occurred in people of the weak temperament type who, during their childhood, developed improperly and were subjected to severe traumatic life experiences at a time when the person was not well established. The inhibitory processes during this period failed to defend the person from terrible overexertion. This may have led to physiological damage to the highest regions of their central nervous system. As therapy for schizophrenia, Pavlov recommended rest and prolonged sleep that was induced by soporific pharmaceuticals (Windholz & Witherspoon, 1993).

In the 1920s, Pavlov, as he was getting older, became interested in senescence, after observing the aging process in himself and in others. When the Pavlovians performed experiments on old dogs, they determined that salivary conditioned responses acquired early in life persisted into old age, but these dogs could not easily acquire new reflexes. Pavlov attributed the disturbances of the dynamic stereotype, poor adjustment, and declining sensory-motor abilities to the overall weakening of neural processes, with the decline of the inhibitory process steeper than the decline of excitatory processes. This discrepancy manifested itself in the garrulousness of the aged when the excitatory processes furthered their talk, but the sharp decline of inhibition failed to restrain their words (Windholz, 1995).

Pavlov's Advocacy of Human Rights

To take a full measure of a human being, his or her personality and attitudes should be considered. Although almost completely immersed in science, Pavlov, a Russian patriot, was active in the social and political life of his country. Denied permission to emigrate by Lenin, Pavlov, in university lectures, attacked the Soviet regime's destructive policies. Undaunted by the regime's practice of "liquidating" people on mere suspicion of opposition, Pavlov, who was devoted to the search for scientific truth, condemned the prevarications of the Soviet regime and openly defended human rights; academic freedom; and, although himself irreligious, the toleration of religious expression (Todes, 1995).

Pavlov's Achievements and Their Consequences

Woodworth (1948) recognized early that Pavlov's theory of higher nervous activity was essentially an association

learning theory akin to that proposed by Thorndike (1911) and Hull (1943). As such, it is now mainly of historical interest. In contrast, Pavlov's method of salivary reflex conditioning became paradigmatic for the various subsequent, nonoperant conditioning methods. Similarly, some Pavlovian concepts, such as reinforcement, extinction, and generalization, became integral to modern psychology. Other Pavlovian concepts, such as the dynamic stereotype or the paradoxical and ultraparadoxical phases, deserve serious attention and further experimental clarification.

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