

A Note on Skinner and Pavlov's Physiology

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These short notes describe the way in which Skinner considers and resolves his differences with Pavlov in the question of the relation between psychology and physiology as forms of knowledge. After establishing his viewpoint in the general epistemological issue, Skinner is concerned about linking his study of behavior to the work of Pavlov, who considered it to be of a physiological nature. Skinner contrasts Pavlov's empirical and theoretical work and characterizes the latter in terms of the notion of the "Conceptual Nervous System."

Keywords: Skinner, Pavlov, Psychology, Physiology

Se analizan en estas breves notas el modo en que Skinner plantea y resuelve sus diferencias con Pavlov respecto a la relación entre psicología y fisiología como formas de saber. Tras establecer su punto de vista en la cuestión epistemológica general, Skinner se preocupa de vincular su estudio de la conducta con la obra de Pavlov, que éste considera fisiológica por naturaleza. Skinner contrapone el trabajo empírico y el trabajo teórico de Pavlov y caracteriza el último en términos de la noción de "Sistema Nervioso Conceptual".

Palabras clave: Skinner, Pavlov, Psicología, Fisiología

It goes without saying that there are many ways in which Skinner can be associated with Pavlov. One could say that they comprise a related pair in many psychology texts and also, to use a terminology that would be novel to them, that the name of one of them “primes” that of the other in the short-term memory. Speaking less rhetorically, one gets a strong feeling of unity between the works of Pavlov and Skinner, and the progress of the one over the other is continuous rather than discontinuous.

However, a main and evident discrepancy can be noted between these authors in the relation between psychology and physiology as fields of knowledge. Pavlov and Skinner have different and characteristic viewpoints about this epistemological issue (that, ultimately, has to do with the foundations of psychology), which—one would suppose—would cause their works to go in essentially divergent directions, but which, however, does not occur. The purpose of these notes is to analyze the way that Skinner copes with and resolves—if he actually does so—this doctrinal difference with Pavlov about the epistemological foundation of psychology or, in other words, the value and scope he assigns to the difference. In the end, the object is to bring up one more episode, perhaps a trivial one, in the extensive and confused history of the epistemology of psychology.

Physiology and Psychology in Pavlov and Skinner

As though he wished to first limit the terrain in which he would move about, Pavlov proposes the relation between physiology and psychology in the first pages of *Conditioned Reflexes* (Pavlov, 1927). His treatment of the issue is summary—which Pavlov himself regrets—but in any case, he leaves no doubt about his point of view. Skinner is concerned with the relation between psychology (or the study of behavior) and physiology, in more detail and more elaborately than Pavlov. In his classic work, *The Behavior of Organisms* (Skinner, 1938), and when collecting prior notions (Skinner, 1931/1961), Skinner establishes a viewpoint that he will subsequently not change, although he often refers to this issue.

Pavlov

Pavlov begins by wondering whether, in order to explain the activity of the brain’s hemispheres, “he [the physiologist] should first of all study the methods of this science of psychology, and only afterwards hope to study the physiological mechanisms of the hemispheres” (Pavlov, 1927, p. 3). The answer is negative. And it is negative because, for Pavlov, psychology might not be a scientific activity, and is certainly not a natural or exact science.

[I]t is still open to discussion whether psychology is a natural science, or whether it can be regarded as a science at

all. [...] Even the advocates of psychology [James, Wundt] do not look upon their science as being in any sense exact (p. 3).

Therefore, if physiology were built on psychology, then “we shall be building our superstructure on a science which has no claim to exactness even compared with physiology” (p. 3).

For Pavlov (1927), psychology refers to “some kind of special psychical activity, whose working we feel and apprehend in ourselves, and by analogy suppose to exist in animals” (p. 3). The concepts and methods of psychology are of a subjective and anthropomorphic nature that deprives psychology of any value as a form of scientific-natural knowledge. And this is because scientific-natural knowledge, of which physiology is a part, is characterized by the use of objective methods and is beyond the scope of subjective methods. (With regard to these, Pavlov states that “As a result of this investigation [early research with the so-called psychic secretion], an unqualified conviction of the futility of subjective methods of inquiry was firmly stamped upon my mind” [p. 6]). In short, due to the nature of its methods and concepts, psychology is an intellectual enterprise foreign to natural science and, therefore, to physiology. It is important to note that Pavlov’s considerations about psychology refer to psychology in its developmental status at that time, and the declaration of independence of physiology is also based on that developmental status. But ultimately, psychology could become a “true science” if, for that purpose, it sought support in the “experimental investigation of the physiological activities of the hemispheres.”

One could say then, that, for Pavlov, psychology does not exist as a natural science but that, once it acquires that nature, which it could thanks to physiology, it would still not be a foundation of physiology, but would depend on physiology and find its ultimate explanation in physiology. In this sense, Pavlov attributes to his work the significance and the merit of having rescued the study of the conditioned reflexes from the mud of psychology, bringing it to the firm ground of natural science. Pavlov thinks that thanks to his work:

[T]heir activities [of the cerebral hemispheres] are studied as purely physiological facts, without any need to resort to fantastic speculations as to the existence of any possible subjective states in the animal which may be conjectured in analogy with ourselves (Pavlov, 1927, p. 16).

Now—Pavlov believes—it is possible to say that “‘education,’ ‘habits,’ and ‘training’ and all of these are really nothing more than the results of an establishment of new nervous connections during the post-natal existence of the organism” (p. 26).

Skinner

Skinner (1938) wonders whether “the all but universal belief that a science of behavior must be neurological in

nature" (p. 418) is true. He expresses his disagreement with this opinion and, in contrast, supports the conceptual and empirical singularity of the study of behavior and its independence of physiology. In his own words: "I am asserting, then, not only that a science of behavior is independent of neurology but that it must be established as a separate discipline whether or not a rapprochement with neurology is ever attempted" (Skinner, 1938, p. 423).

In order to refute them, Skinner identifies various arguments in favor of neurologization. The argument to which he concedes special importance and that he wishes to refute above all the others is the one that, based on the idea that neuronal activity is more fundamental than behavior, lends reductive priority to physiological events and asserts that behavior cannot be explained as long as we do not know the correlative neurological phenomena. On the contrary, for Skinner, the laws of behavior—laws that allow the prediction and control of behavior—can be established without any mention or knowledge of the organism's physiology, and they cannot be explained, or, evidently, invalidated in terms of physiology (see Verplanck, 1954, p. 303).

Skinner asserts that:

The discovery of neurological facts may proceed independently of a science of behavior if the facts are directly observed as structural and functional changes in tissues, but before such a fact may be shown to account for a fact of behavior, both must be quantitatively described and shown to correspond in all their properties (Skinner, 1938, p. 422).

and that:

The very notion of a "neurological correlate" implies what I am here contending—that there are two independent subject matters (behavior and the nervous system) which must have their own techniques and methods and yield their own respective data. No amount of information about the second will "explain" the first or bring order into it without the direct analytical treatment represented by a science of behavior (Skinner, 1938, p. 423).

And with echoes of Wittgenstein: "No merely endocrinological information will establish the thesis that personality is a matter of glandular secretion or that thought is chemical" (Skinner, 1938, p. 423). Finally, as the previous statements anticipate, even admitting the independence between psychology and physiology, if one wished to establish a relation between them, one would have to take into account that "they [the laws of behavior] actually impose certain limiting conditions upon any science which undertakes to study the internal economy of the organism" (Skinner, 1938, p. 432).

Later on, Skinner (1950) will give another shape to his arguments and will express his doubts about the function of theories, denying their usefulness for the study of

behavior. A theory is "any explanation of an observed fact which appeals to events taking place somewhere else, at some other level of observation, described in different terms, and measured, if at all, in different dimensions" (p. 39). Among these useless theories that rather confuse research are the physiological theories. Skinner points out that, although in neurophysiology the references to physical operations of the nervous system are not theories in this sense, in a science of behavior, on the contrary,

all statements about the nervous system are theories in the sense that they are not expressed in the same terms and could not be confirmed with the same methods of observation as the facts for which they are said to account (Skinner, 1950, pp. 69-70).

Independence and Contradiction

Up till now, one can observe, on the one hand, a formal community between Pavlov's and Skinner's arguments which should be noted. Both of these authors, after identifying two fields of study or knowledge, maintain the methodological and conceptual independence of these fields and the need to develop them separately. In practice, any researcher who devotes himself to one discipline can forgo the other with no qualms or misgivings.

On the other hand there is, of course, a fundamental difference that emerges from the claim of independence made in each case for different, and even contradictory, reasons. For Pavlov, physiology and psychology are independent because psychology lacks meaning as a natural science. And, in any case, in order to have meaning, it should lean on physiology, to which it can, ultimately, be reduced. Skinner, in contrast, considers that psychology, as the study of behavior, is a natural science, as his own work demonstrates, and therefore it is independent of and cannot be reduced to physiology. It should be noted that Skinner does not refer to this difference of opinion explicitly and does not turn it into a matter of confrontation with Pavlov. At this level of theoretical foundation, there is an evident contradiction between Skinner and Pavlov that the former avoids considering, perhaps so as not to emphasize his differences with Pavlov. The contradiction, if it really exists, is still not resolved.

Conversely, one could also deny the contradiction. Thus, it is true that the things that Pavlov and Skinner compare to physiology are different terms and entities. It must be taken into account that, as noted, Pavlov uses the term "psychology" to denote the introspective psychology of the late 19th century. On the other hand, Skinner does not relate that kind of psychology to physiology, but instead "the study of behavior" that becomes firmly fixed in the first third of the 20th century, and which Pavlov essentially did not know when he published *Conditioned Reflexes*. And Skinner would doubtless literally subscribe to many of Pavlov's statements about the introspective psychology of the 19th century. (The

latter had written that the work of the small group of American “behaviourists” could be considered “as purely physiological in character” [Pavlov, 1927, p. 7]). From this viewpoint, it could be concluded that there is no opposition between Skinner and Pavlov, because what they are comparing and relating to physiology are different fields of study or sets of phenomena.

However, in any case, Skinner forgets about Pavlov regarding the basic epistemological issue of the relation between psychology and physiology and lays aside their differences about this without lingering over them. Concerning Pavlov, Skinner tries to answer a different question related to the general issue but, so to say, more concrete, and referring in particular to Pavlov’s work. In its essential terms, the question is: If Pavlov was devoted to the study of the “higher nervous activity,” by which can be understood the physiological processes that occur in the cerebral cortex, that is, given that Pavlov was a physiologist, how can his work fit in a study of behavior that is declared to be conceptually and methodologically independent of physiology? What value can Pavlov’s methods and findings, manifestly those of a physiologist, have for psychology as the study of behavior? Skinner’s answer is preceded by a series of considerations and concepts that are outlined below.

Ways of Physiologizing

Skinner distinguishes two practical manifestations of the argument in favor of neurologization or, in other words, two modes or levels of explanation of behavior in physiological terms.

The Conceptual Nervous System

According to Skinner, there is a first level where the physiological explanation consists of a series of local references, neurological in that sense, among which are noteworthy the synapse and its various states, such as conductivity, excitability, or resistance. However, these references are not derived from direct observation of the nervous system as a real structure that undergoes physical-chemical changes, but from a comparison of the input with the output that is very similar to that employed in the case of behavior. At this level of physiologizing, a framework of new references is introduced; the behavioral data are formulated in different terms as laws of synapse. But ultimately—Skinner (1938) insists—there are few differences between this type of concepts and neurological laws and the concepts and laws that are established in the study of behavior. “The data upon which the system is based are very close to those of a science of behavior, and the difference in formulation may certainly be said to be trivial with respect to the status of the observed facts” (p. 421).

As an example of this kind of explanation, Skinner takes the well known and influential work of Sir Charles Sherrington *The Integrative Action of the Nervous System* published in 1906. In his work, Sherrington (as cited in Skinner, 1938) points out that the reflex action of a spinal dog manifests different properties from those observed in preparations in which the spinal cord does not intervene and conduction is restricted to a section of the motor nerve trunk, as in the so-called nerve-muscle preparation. Sherrington links these differences between conduction in the reflex arch and conduction in the nerve trunk to the existence of a synapse, or separation surface between the adjacent nervous cells in the reflex arch, to which he attributes a certain number of states and processes of various natures. Skinner argues that the empirical data of the British physiologist are almost exclusively concerned with the behavior of the animal when faced with some kind of stimulation, so that the properties of the synapse are inferred from the properties of the relation between the stimulus and the response, and this information is what constitutes the basis of his teachings about the nervous system. Thus, the statement that repeated afferent firing produces an increase in synaptic resistance or a decrease in excitability—according to Skinner—reflects the behavioral fact that the repetition of an afferent firing in a certain temporal sequence provokes progressively weaker efferent firings. One could say that the language gets changed but not the facts to which it refers.

To describe this level of physiologizing, Skinner introduces the notion of the conceptual nervous system. In “The Concept of the Reflex in the Description of Behavior” he asserts that the synapse, as analyzed and described by Sherrington, “[...] is the conceptual expression for the conditions of correlation of a stimulus and response, where the incidental conditions imposed by a particular stimulus and a particular response have been eliminated” (Skinner, 1931/1961, p. 335, no emphasis added). In *The Behavior of Organisms* Skinner generalizes this—one could say—notion of conceptual synapse to suggest that physiology of the reflex at this level of elaboration, rather than being concerned with what is traditionally known as the C.N.S. (Central Nervous System), is instead concerned with what could be called the “Conceptual Nervous System” (Skinner, 1938, p. 421).

Skinner argues that, as there is no—nor is any intended—direct observation of the nervous system as a physical entity, what is implied and described at this level of neurologization is not the central nervous system but a conceptual nervous system. By a conceptual nervous system (CONS) Skinner means a purely abstract and conceptual system—a being of reason, as a Scholastic would say—, with which one tries to explain or justify behavior by means of a series of elements and action schemes that, to some extent, mimic or are inspired by the action of the nervous system. In other words, in a CONS, the neurological correlate of a behavioral fact is purely “inferential” and abstract, deprived of any physiological reality. In “Are

Theories of Learning Necessary?" (Skinner, 1950/1961), he will come back to the CONS, showing it as a notion that is applicable to a way of theorizing—or perhaps “modelization”—that is increasingly popular:

The writer's suggestion that the letters CNS be regarded as representing, not the Central Nervous System, but the Conceptual Nervous System seems to have been taken seriously. Many theorists point out that they are not talking about the nervous system as an actual structure undergoing physiological or biochemical changes but only as a system with a certain dynamic output (p. 40).

“Real” Physiology

Skinner distinguishes and separates from the former level a second level of physiologizing which, he says, is the truly physiological level, where the object of research and analysis is the nervous system itself.

At this level, according to Skinner (1938), the neurological correlate is sought in terms of a more complete local reference that is based on direct observation of the synaptic or nervous processes in question. In other words, in this case, the neurological correlate has its own reality and the data refer to a certain type of structural and functional changes in the tissues expressed as physical-chemical terms and concepts. Thus, whereas at the former level, the strength of the reflex becomes synaptic conductivity, now “the notion of synaptic conductivity is to be translated in terms, say, of permeability or ionic concentration” (p. 422). At the “physical-chemical” level—that Skinner also calls the level of “real” physiology—the data are not behavioral data expressed in other terms, but data about another kind of facts and for which is needed a different dimensional system from the one corresponding to the data—also called physiological but ultimately behavioral data—that are considered at the previous level.

It should be noted that this level of, so to say, hard and fast physical-chemical neurologization is usually taken as *ultima ratio* of the study of behavior and the level at which are aimed the arguments of *The Behavior of Organisms* in favor of the need to study and explain behavior independently and in its own terms. Regarding the first conceptual and abstract level, Skinner makes another kind of consideration. Each of the levels of neurologization implies a different explanation mode and, therefore, deserves a different rebuttal.

Pavlov and the Conceptual Nervous System

For Skinner, Pavlov's physiology is a way of conceptual neurologization, at the first level, so the value and meaning of Pavlov's work is discussed from the viewpoint of the conceptual nervous system.

Pavlov's Level of Physiologizing

Skinner considers that the physiology that Pavlov says he studies is, perhaps to a greater extent than that of Sherrington, a purely abstract conceptualization and which, independently of the nature of the terms he uses, is entirely derived from the conditions of the relation between the environmental events and the organism's movements. Pavlov's data are behavioral data, obtained from pure observation of the activity of the animal in interaction with its environment, without considering local, physiological, or biochemical changes undergone by the nervous system. And the data are still behavioral data, despite the fact that Pavlov, resorting to a certain language, formulates them as physiological concepts and laws.

About Pavlov's main work, Skinner states:

The subtitle of his *Conditioned Reflexes* is ‘An investigation of the Physiological Activity of the Cerebral Cortex,’ but no direct observations of the cortex are reported. The data given are quite obviously concerned with the behavior of reasonably intact dogs, and the only nervous system of which he speaks is the conceptual one (Skinner, 1938, p. 427).

According to Skinner, Pavlov does not practice “real” or “physical-chemical” physiology, but rather, regarding his work, one can only talk about physiology in a conceptual sense. One could say that, for Skinner, the Pavlovian notion of nervous connection between the center or “analyzer” of the CS and the US, for example, is nothing more than an abstract concept based on physiology but without any physical reality or capacity to explain behavior beyond expressing certain behavioral realities. Skinner's more or less explicit conclusion is that “higher nervous activity” is just Pavlov's name for behavior or for behavior described in terms of a CONS.

Therefore, Skinner's issue with Pavlov, so to say, is not Skinner's issue of with “real” or “physical-chemical” physiology, which Pavlov supposedly did not practice; instead it is the issue of Skinner's critique of the CONS, which, according to Skinner, Pavlov is dedicated to build.

The Critique of the Conceptual Nervous System and the Valuation of Pavlov's Work

As Pavlov was devoted to the CONS, Skinner's judgment of the value of this kind of systems should determine his appraisal of Pavlov's work and of its pertinence for the study of behavior. However, as will be seen below, this is not exactly what happens: The valuation of Pavlov's work seems to affect the estimate about the CONS, which is modified when referring it to Pavlov.

The critique of the Conceptual Nervous System. On the one hand, Skinner (1938) finds some not minor objections—or perhaps no advantages—to the use of the CONS as an

explanatory tool or means of knowledge. Chiefly, the CONS facilitates or conceals the commission of essential errors, such as attributing behavior to a nervous fact and seeking the explanation of the laws of behavior in physiology. By its own nature, which mixes observations and its interpretation in certain terms, the CONS is equivocal and causes confusion about the place it occupies and the explanations it provides: “the use of terms with neural references when the observations upon which they are based is misleading” (Skinner, 1938, pp. 426-427).

From the viewpoint of the ultimate explanatory value of the CONS, Skinner reviews some of its characteristic constituent elements—such as “the connective network which is offered to account for the topographical relations of stimuli and responses” (Skinner, 1938, p. 421) — to point out that “the essential advance from a description of behavior at its own level is, I submit, very slight” (p. 421). The CONS does not introduce more order or clarity in the data nor, contrary to some people’s assumptions, does it contribute to affirming the regularity of the relations between the stimulus and the response. In a more subjective vein, Skinner finally points out: “An *explanation* of behavior in conceptual terms of this sort would not be highly gratifying” (Skinner, 1938, pp. 421-422, no emphasis added).

Pavlov and the use of the Conceptual Nervous System.

The tone of the critique becomes weaker when relating the CONS to Pavlov. Then, resorting to the CONS constitutes “a legitimate procedure” (Skinner, 1938, p. 427). But, of course, a legitimate procedure insofar as its usage rules are respected. That is, insofar as the behavioral data are not substituted by another kind of data; and insofar as “the laws established are not turned to ‘explain’ the very observations upon which they are based” (p. 427). Apparently, Pavlov takes these restrictions into account, and Skinner finds nothing with which to reproach him regarding the CONS.

In effect, faced with the errors that the CONS can facilitate, Skinner insists that Pavlov’s data are behavioral data, whose primacy is respected without being substituted by any other kind of data, independently of the language in which they are conceptualized. Regarding the chief error that the CONS promotes, Skinner does not wonder whether Pavlov shares the opinion of those who erroneously think that physiology is, say, the ultimate explanation of behavior. It is noteworthy that, as an example of the incorrect use or abuse of the CONS as an explanation of behavior, Skinner (1938) quotes Holt and, surprisingly, Holt’s employment of Pavlov’s concepts, without exactly linking Pavlov to the error (p. 427).

Summing up, the CONS, as probably is the case with other ways of theorizing, can be used appropriately, but it can also be improperly used and constitute a source or errors and mixtifications. One might even say that the CONS is particularly prone to deviated usage. But, in any case, Pavlov is a privileged and irreproachable user. Whatever the errors

induced by the CONS, Skinner is not willing to accuse Pavlov of these errors, although it is unlikely that Pavlov did not commit them. As mentioned above, Skinner’s consideration of the CONS seems to be one kind when it is about the CONS itself and a different one when it is associated with Pavlov. In the first case, Skinner primarily mentions the mistakes and errors to which the CONS lends itself and the few advantages that it, in fact, offers; where Pavlov is concerned, the problems of the CONS are usage problems which Pavlov avoids.

To conclude, it is obvious that when characterizing Pavlov’s work in terms of the CONS—insisting on its correct use—Skinner deprives the Russian’s work of its physiological character *propie dicto* and reclaims it as a work whose true issue is behavior. Skinner’s considerations about Pavlov’s work are guided by the idea that: (a) In Pavlov’s work, there is an important series of methods, findings, and procedures strictly referred to behavior; and (b) the value of these findings should be deemed independently of the physiological-conceptual theories that Pavlov builds based on them. In Skinner’s analysis, Pavlov is an investigator of behavior and only nominally or for himself a physiologist. As a description—and praise—of Pavlov’s work, Skinner (1953) writes: “Pavlov’s achievement was the discovery, not of neural processes, but of important quantitative relations which permits us, regardless of neurological hypotheses, to give a direct account of behavior in the field of the conditioned reflex” (p. 54).

Skinner’s Reasons

One could state that, with regard to Pavlov, Skinner has to reconcile two strategic aims that, at first glance, seem mutually exclusive. On the one hand, as seen more than once, Skinner feels the need to establish psychology or the study of behavior independently of physiology. As Verplanck (1954) has pointed out, Skinner’s “axiom” about the independence of psychology from physiology “permits Skinner to proceed with his experimental investigations and system-building without reference to the physiology of the organism or to the structure and function of the neuro-skeletal system” (p. 303). And Timberlake (1988) states that, for Skinner “to achieve his aim of a common framework for the study of purposive and reflexive behavior”, it was imperative to free the concepts of stimulus, response, and reflex from their obvious physiological connotations. “To fail in this was to disallow the jump from reflex to purpose, because it was clear that purposive behavior depended on more than the restricted set of neurological pathways determining spinal reflexes” (p. 305).

Skinner’s other goal was to reaffirm the value of Pavlov’s work, on which his own work is based. This is not the appropriate place to analyze aspects of the relation between Skinner and Pavlov that do not refer to the epistemological

issue of psychology and physiology, but, in any case, the close experimental and conceptual link of the former researcher with the latter should be noted. Skinner's contribution to the study and conceptualization of behavior consists, to a great extent, of having pursued with a new and broader scope procedure—operant conditioning—the research program developed by Pavlov with his own procedure. In sum, Pavlov's methods and findings provide the immediate empirical foundation for Skinner's work. The former statement is made without a trace of the derogatory tone used by some of Skinner's critics or Pavlov's enthusiasts when mentioning this fact. If Pavlov invented an experimental program, the best thing that Skinner could do was to adopt it.

Skinner's solution, as seen, has two parts. On the one hand, he ignores or conceals his differences with Pavlov about the function of physiology in the study of psychology, not mentioning him when addressing the issue. On the other hand, Skinner makes an effort to leave safe and sound the value of Pavlov's work for the study of behavior. With this aim, he distinguishes an empirical aspect and a theoretical or conceptual aspect in the Russian's work, to disconnect the former from the latter and to reveal the empirical side as part of the study of behavior, which, therefore, is within the field of the researchers dedicated to behavior. Thus, Skinner is in a position to vindicate a way of working that is not at all physiological and that, however, is closely related to Pavlov's way of working.

This interpretation of Pavlov as a student of behavior seems correct and helps to understand the nature of his work. In other important researchers of animal learning, closer to Pavlov in the issue of the psychology-philosophy relationship, one finds a confusing and equivocal interpretation of Pavlov. Such is the case of C. L. Hull, who in his systematic work *Principles of Behavior* (1943) reveals his propensity towards Pavlov's epistemological stance with the statement that "nearly all serious students of behavior like to believe that some day the major neurological laws will be known in a form adequate to constitute the foundation principles of a science of behavior" (p. 19). However, when mentioning Pavlov, Hull refers to his experiments as experiments about "the molar behavior of organisms, usually as integrated wholes" (p. 20), in accordance with Skinner's considerations. Nevertheless, Hull also states that the object of these experiments were "the coarse, or 'molar,' laws of neural activity as revealed by conditioned-reflex and related experiments" (p. 29). From which one can conclude that, for Hull, Pavlov is a physiologist, although not of molecular nervous activity, but of molar behavior or the organism as a whole. And in order to effectively link Pavlov with physiology, Hull compares Pavlov's molar laws with "the molar mechanics of the physical world [Galileo and Newton]" that have preceded and made possible the "micro-mechanics of the atomic and subatomic world", that is, "the molecular science of modern relativity and quantum theory [Einstein,

Planck]" that correspond with molecular neurology (see Hull, 1943, p. 20). For Hull, then, one could say that Pavlov's work is a way or stage of physiology that will finally lead "to a truly molecular theory of behavior firmly based on physiology" (p. 20).

One last consideration with regard to the idea of the CONS. Following Skinner, one could define as conceptually physiological—or call it a CONS—any abstract system made up of a number of structurally interrelated centers, to which one assigns sensory or motor activity and the capacity of transmitting, by activation or inhibition, a kind of energy theoretically linked to the nervous impulse. Perhaps this is the first time a concept is elaborated—or an expression is coined—to represent those models that employ abstract functional elements and properties taken from physiology as an illustration or justification of certain regularities observed in the study of behavior. (At one time [Gray, 1979], the concept of CONS was erroneously attributed to D. O. Hebb, who simply used it in the title of a well-known article [Hebb, 1955]). It can be noted that a CONS is, of course, a mechanical model, in the sense that it derives its explanatory capacity from a notion of purely physical causality (Dickinson, 1989); but it is also a special kind of mechanical model with original properties.

There is a broad range of models or theoretical constructions that could be thus characterized. In the study of animal learning, an example of CONS prior to Pavlov is, for example, the physiological mechanism that C. L. Morgan (1894) proposed to explain the physical connection that underlies the association of ideas. And a recent example of CONS is the one elaborated by the connectionist systems, whose elements are defined or described as "neuron-like" units or abstract neurons. If a connectionist system is conceived as a level of implementation, its characterization could be completed by saying that it is a physiological implementation of an abstract nature, and that what it simulates or refers to is not the central nervous system but the conceptual nervous system.

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