Hypnosis and Inhibition as Viewed by Heidenhain and Pavlov

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Abstract—About 1880, Rudolf Heidenhain, then Professor of Physiology and Histology at the University of Breslau, experimentally studied hypnotic phenomena. Heidenhain explained hypnosis physiologically, in terms of cortical inhibition. Subsequently, I. P. Pavlov, who in 1877 and again in 1884 was Heidenhain's student at Breslau, encountered hypnotic phenomena during conditional reflex experiments. In 1910, Pavlov described hypnotic states and explained them (as had Heidenhain three decades earlier), in terms of partial inhibition of the cortex. As the concepts of inhibition and excitation are cornerstones of Pavlov's theory of higher nervous activity, it is of historical interest to search for influences that led Pavlov to incorporate the concept of inhibition into his theory. It is most likely that Pavlov first encountered the concept of central inhibition in the 1860s when reading I. M. Sechenov's *The Reflexes of the Brain* (1863/1866) and that the importance of the concept was augmented by Heidenhain's use of it in explaining hypnotic phenomena.

ON OCTOBER 23, 1897, I. P. Pavlov, speaking before the Society of Russian Physicians in St. Petersburg, delivered a eulogy on the life and work of the recently deceased University of Breslau Professor of Physiology and Histology, Rudolf Heidenhain (Pawlow, 1954).

Pavlov had much to say about Heidenhain because he worked twice in his Breslau Laboratory: from June to August 1877 and again in June 1884 (Gureeva and Chebysheva, 1969). Reflecting on the personality of Heidenhain, Pavlov described him reverentially:

> As a teacher, Heidenhain was a fascinating personality; simple, attentive, extremely interested in everything and happy when his students were successful. His expansiveness, his action, united the entire laboratory. He deeply felt every activity in his laboratory, he saw to it that everyone became interested in the work so that we not only were concerned with ourselves, but with the successes and failures of the entire laboratory. In addition, he had a precious trait; until his old age he preserved his childish soul, his heartfelt goodness, so that he could not deny an insistent request. This rare trait I have seen in another teacher too—in Ludwig. How have they maintained it? Very simply, gentlemen! They spent their entire lives within the walls of the laboratory, between books, equipment and experiments, where the only honor, only one satisfaction, only one attachment and passion, was the search for truth. (Pawlow, 1954, p. 82)

Pavlov pointed out that Heidenhain's life was bereft of dramatic events. Heidenhain was

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born in 1834 at Marienwerder, in western Prussia. For two years he attended the University of Königsberg, where he initially studied natural science but then switched to the medical school. Next he went to the University of Halle. Heidenhain received an MD degree from the University of Berlin in 1854, where he worked under the direction of Emil Du Bois-Raymond. Subsequently, he worked at the University of Halle until 1859, when he was called to the University of Breslau as Professor of Physiology and Histology. There he was the director of the Physiological Laboratory and trained numerous students, among whom was Pavlov (Grützner, 1898).

Heidenhain's many scientific achievements were described at some length by his biographers (Grützner, 1898; Pawlow, 1954; Rothschuh, 1953; Voit, 1898), whose works will not be discussed here. Suffice it to say that among Heidenhain's major contributions to physiology, his experiments on the function of the glands were the most important. He began the investigation of glands in 1867, and in 1883 presented in the *Handbuch der Physiologie* a truly encyclopedic description of the histology and function of various glands.

In the late 1870s, Heidenhain began the experimental investigation of hypnotic phenomena. Pavlov was fully aware of this phase of Heidenhain's work, which he mentioned in Heidenhain's eulogy:

> At that time European society became interested in the experiments of the professional hypnotist Hansen. Heidenhain saw these experiments in Breslau and immediately replicated these and in this way he was one of the first, along with Charcot, to show that the field of hypnosis is profoundly genuine [phenomenon] and of considerable scientific significance. (Pawlow, 1954, p. 74)

The general aim of this article is to determine Heidenhain's influence on Pavlov's conceptualization of the theory of higher nervous activity. In particular, my thesis is that Pavlov's conceptualization of inhibition, an integral aspect of his theory of higher nervous activity, was to a considerable extent based upon Heidenhain's concept of inhibition as explained in his description of hypnotic phenomena.

The Background for Heidenhain's Experiments on Hypnotic Phenomena

About 1880, the hypnotist Hansen performed in Breslau, to the astonishment of townspeople, "magnetic" phenomena. On Hansen's order, on the stage, "magnetized" Breslau citizens ate potatoes convinced that they were apples, rode in mock "races" sitting astride chairs, and were unable to recall their own names. The public became excited by Hansen's demonstration. The observed phenomena became a matter of debate. Some maintained that these were cheap tricks, others, of a mystical bent challenged science to explain what they had seen (Grützner, 1898).

Heidenhain, known for his sense of humor, secretly persuaded some young people at a party to play the role of hypnotized "mediums" while he would pretend to be the hypnotist. The fun backfired when, to Heidenhain's amazement, his younger brother responded hypnotically to his play-acting and could not be easily restored to a normal condition! From that time on, Heidenhain took hypnosis seriously and began using his brother as well as other members of the university community as "mediums," to perform a series of hypnotic experiments at the Breslau Physiological Institute (Grützner, 1898). Heidenhain presented the results of these experiments on January 19, 1880, in a popular lecture delivered before

the Silesian Society of National Culture. These results were later published. The aim of the lecture was to debunk mystical claims by showing that hypnosis was a natural phenomenon that could be studied by the scientific method.

Heidenhain's Conceptualization of Hypnosis

Heidenhain (1880) described the phenomenon of hypnosis on two conceptual levels, behavioral and physiological. On the behavioral level he considered the overt actions of the hypnotized subjects. The explanation of the underlying mechanisms of hypnosis was in terms of hypothesized physiological processes.

The Precondition, Induction, and Cessation of the Hypnotic State

The precondition to the inducement of the hypnotic state is a general excitation of the nervous system. The hypnotist may evoke this excitation by asking the subject to look at a crystal ball. Yet, not every individual is susceptible to hypnosis. The most susceptible individuals are those who are easily excited, anemic, or heavily muscled. The latter condition, which involves muscle contraction, makes it easier to fall into the cataleptic state.

Hypnosis was induced in human subjects by the repetitious presentation of weak, monotonous stimuli of either a visual, an auditory or a tactile modality. Direct stimulation of facial tissue by slightly touching the face was also effective. The cessation of the hypnotic state was brought about by the presentation of sudden, powerful stimuli.

The Hypnotic State

The hypnotic state differs from the nonhypnotic in terms of sensitivity to presented environmental stimuli without consciousness of the sensations. The lack of conscious realization of the sensory stimulation was the consequence of the failure of the attentive processes. Heidenhain (1880) maintained that sensation and consciousness of sensory impression are, fundamentally, two separate psychological processes. He elucidated the independence of these processes by pointing out that an individual may hear other people's voices, yet not know their meaning due to the failure to concentrate on what was said. He also gave as an example the sleeping mother who does not awaken to many loud sounds but becomes conscious of her child's whimper.

Deeply hypnotized subjects, after emerging from the hypnotic state, do not recall their experiences during the hypnotic state. This condition resembles dreaming. However, if the recall occurs after the hypnotic state, and if the hypnotist provides some clues to the events during the hypnotic state, the subject recalls these events. In contrast, events performed in a light hypnotic state are recalled after the hypnotic state with relative ease.

Hypnotic Suggestibility

Hypnotic suggestibility, according to Heidenhain (1880), entails the evocation of unconscious movements in response to sensation. That is, the hypnotist's movements are noted by the hypnotized subject, although these movements are not registered consciously. The hypnotized subject imitates the hypnotist's movements, provided that such movements impinge on the subject's senses. Thus, when the hypnotist gives an order, the hypnotized subject does what the hypnotist's order suggests, even though the subject is unaware of its

purpose. When a verbal order is not executed, after the hypnotist performs the movements requested, the hypnotized subject may unconsciously perform these movements. Thus, the hypnotist Hansen asked the subject to eat a potato, saying that it was a pear, and then performed chewing movements. The subject responded to it automatically by chewing the potato.

Heidenhain described some additional facts. He observed that the absolute threshold of a hypnotized subject is, in comparison to normal subjects, very high. Hypnotized subjects did not experience pain when subjected to noxious stimuli, yet were at the same time sensitive to tactile stimuli, such as being touched by a small brush. As soon as the hypnotic state ended the subjects regained the sensation of pain.

The magnitude of muscle reflexive contractions was exaggerated under hypnosis. In contrast to nonhypnotized subjects, the reflexes of hypnotized subjects radiate rather slowly, but the muscle contractions are powerful. Gentle stroking of the skin triggered muscle contractions that lasted for a longer time period. The net effect was a muscle contraction that affected some other bodily parts. In the case of individuals with well-developed musculature, the body became stiff as a board. This condition reminded Heidenhain of the nervous system disorder known as catalepsy. The similarity of the muscle contraction found in hypnotized subjects and catalepsy led Heidenhain to the conclusion that hypnosis was artificially produced catalepsy.

The Explanation of the Hypnotic State

Heidenhain explained the hypnotic phenomena physiologically. He hypothesized that these phenomena involved certain changes in the brain and the brain stem:

> We know that the function of consciousness is dependent on the integrity of the gray cortex of the large brain. Because the consciousness of the hypnotized [person] is much depressed, it becomes obvious that there is a functional diminution [of the efficiency] in the surface regions of the brain-hemispheres. (1880, p. 32)

Heidenhain postulated about which regions of the central nervous system were involved. He doubted that hypnosis was associated with the *corpora quadrigemina* because when one of its regions was destroyed, the pupils of the eyes of animals failed to function, whereas in hypnotized humans the pupils became, in response to light, smaller.

Heidenhain claimed that in hypnotized humans the activity of the cortex was inhibited, but he surmised that this was not the only region of the brain so affected; otherwise, hypnotized humans would behave like decorticated animals, which they did not. Yet Heidenhain was at loss to explain what other parts of the brain were affected in hypnosis.

As hypnosis involved cortical inhibition, Heidenhain wondered what caused this inhibition. Initially, he hypothesized that there was a reflexive constriction of the arterial blood vessels as the result of the sensations that induced hypnosis, and that, in turn, led to the diminution of conscious experience. But Heidenhain dropped this hypothesis because it was observed that constriction of blood vessels leads to facial pallor, whereas hypnotized people's faces reddened.

Heidenhain tended to believe that hypnotic states involve the inhibitory action of ganglion cells in the large hemispheres that are triggered by weak and repetitious stimulation of the facial, visual, or acoustic senses. Heidenhain used the analogy of the functioning of cardiac and respiratory processes. Thus, the changes in the rhythm of the heart were

triggered by the action of ganglion cells that, at certain intervals, stimulated the heart muscles.[1]

Simultaneously, impulses coming through the *vagus nerve* to the ganglion cells inhibited the motor action of the heart. In consequence, the heartbeat was reduced and might even stop. This was the reason, wrote Heidenhain (1880), why the *vagus nerve* was denoted "as the inhibitory nerve of the heart" (p. 36). Similarly, when the sensory nerve of the larynx, namely the *superior laryngeal nerve*, was electrically stimulated, the action of the respiratory muscles slowed down and could cease altogether. This was the consequence of the inhibition of these nerve cells in the brain stem that regulated rhythmic breathing.

Having considered Heidenhain's conceptualization of hypnosis, let us now proceed to the views of I. P. Pavlov.

Pavlov's Conceptualization of Hypnosis

Pavlov's interest in hypnotic phenomena appeared in the first decade of his work with conditional reflexes. In 1910 Pavlov (1951g) gave a speech to the members of a learned society founded by Kh. S. Ledentsov. In his speech he described the methodology and the contemporary status of the conditional reflex theory, including the observation that repetitious application of an identical thermal stimulus to a dog's skin brings about sleep which, later on, Pavlov linked to hypnosis. Like Heidenhain, Pavlov considered hypnosis on two conceptual levels: behavioral and physiological.

The Precondition, Induction, and Cessation of the Hypnotic State

In the September 20, 1933, *Pavlovian Wednesdays*, Pavlov told the participants that he tried to demonstrate to a visitor the conditional reflex method in an already well-conditioned dog. The dog, strapped in the harness, failed to respond and refused to eat. But when released on the floor, it ate. Pavlov explained that the dog's failure to respond when harnessed was the consequence of hypnosis. Hypnosis was induced, explained Pavlov, by two conditions: monotonous acoustic, visual and alimentary stimuli and the restraint of a harness (Orbeli, 1949). Earlier, in 1924, Pavlov (1951c) had stated that hypnosis can be rapidly induced in animals by powerful stimuli.

The technique for the induction of hypnosis in humans was similar to that used with animals. The stimuli, however, were monotonously presented words referring to sleep. These words are conditional stimuli, having been previously associated with sleep (Pavlov, 1951c).

In the 1930s, when Pavlov explored abnormal behavior, he observed the hypnotizing of humans by psychiatrists. In one such case, occurring during the December 9, 1931, *Clinical Wednesday*, the psychiatrist B. N. Birman hypnotized an hysterical woman by telling her that he would count to 15 and she would become somnolent. Indeed, at the count of 14 she closed her eyes and fell on the couch. Then, Birman told her that she was at home asleep and she fell asleep. Next, Birman told her that he would be counting to 10 and at that number she would become awake and vigilant. As soon as Birman reached 10, she awoke and sat down (Bykov, 1954).

The Hypnotic State

In his description of the hypnotic state, Pavlov linked it with sleep. In 1923, Pavlov (1951d) maintained that hypnotized human beings, during and after the induced hypnotized state, completely understand what they are told but are unable to execute movements.

One of first characteristics of hypnosis was catalepsy, the loss of voluntary movements or the inability to change the position of the body once it was set up by some external agent. Hypnotized animals move their eyes but may not be able to eat. Hypnotized subjects do imitate the hypnotist's movements. Old, well-established conditional reflexes are retained in the hypnotic state, whereas newly acquired conditional reflexes are not retained (Pavlov, 1951c).

Pavlov (1951e) stated that during salivary conditioning experiments, hypnosis manifests itself in two states: in the secretion of saliva and in motor behavior. In regard to the latter, a progressive paralysis spreads from the tongue to the chewing muscles, then to the neck muscles, and finally over the entire body.

Hypnotic Suggestibility

Pavlov (1951c) stated that one characteristic of hypnosis is suggestibility, such as the hypnotized subject's conviction that bitter food was sweet. Suggestibility was closely connected with language, an integral characteristic of humans. In adults, words were associated with a broad range of internal and external stimuli and, therefore, were able to evoke a variety of responses. Hence, the word is a conditional stimulus. When, during the induction of hypnosis which, in itself, constitutes a spreading inhibition in the cortex, the word impinges upon the cortex it creates a narrowly defined excitation that competes with other, older traces of excitation. Once the hypnotic state is induced, the hypnotist's words create in the hypnotized subject a powerful activity concentrating on oneself and one's environment. The ability of words to create this powerful impression is due to their recency, brevity, and concentration.

Pavlov's Explanation of the Hypnotic Phenomenon

As early as 1910, Pavlov provided an explanation of hypnosis in terms of the inhibition of cortical processes:

> While ordinary sleep is the retardation, the inhibition of the entire activity of the higher part of the brain, hypnosis has to be understood as the partial retardation of the various areas of this part [of the brain]. (1951g, p. 131)

Twenty years later, in 1930, Pavlov (1951b) reiterated his explanation of hypnosis:

> If on the path of the spreading irradiation over the cortex of the large cerebral hemispheres there are no obstacles such as centers of excitation, you will get ordinary sleep. In the case of a partial envelopment by inhibition of the cortex of the cerebral hemispheres, you will have a partial sleep, a condition which is, usually, called hypnosis. (p. 393)

Similarly, on the October 4, 1933, *Clinical Wednesday*, Pavlov stated that instead of

using the word hypnosis, it is preferable to say "manifestation of inhibition." If, however, this state emerges during a monotonous presentation of stimuli, it is called hypnosis. If the organism encounters a difficult environmental situation, then it defends itself by the retardation of nervous processes (Bykov, 1954). Subsequently, in the February 7, 1934, *Clinical Wednesday*, Pavlov maintained that inhibition is a general concept that in many cases is expressed in terms of hypnotic state (Bykov, 1955).

Influence and Implications

Unlike Heidenhain, Pavlov did not have a program to systematically explore hypnosis. Hypnotic states emerged during the conditional reflex experiments, a disturbing phenomenon because Pavlovian conditioning required an active, vigilant animal. Still, the hypnotic phenomenon could not be ignored, so Pavlov incorporated it in the theory of higher nervous activity. As to the explanation of hypnotic states, Pavlov concurred with Heidenhain's physiological positions; during hypnosis neural inhibition spread over some parts of the cerebral cortex.

Pavlov's inclusion of the concept of inhibition in his theory of higher nervous activity is notable because inhibition as well as excitation are the two cornerstones on which Pavlov's theory rests. Pavlov (1951a) first mentioned inhibition in 1909 only to link it a year later to hypnosis (Pavlov, 1951g). Was Pavlov, then, influenced by Heidenhain's stress of this concept?

Heidenhain (1880) wrote that he derived the concept of inhibition from I. M. Sechenov. Koshtoyants (1964) shows that Sechenov's articles on inhibition were first published in German in 1865. In 1922, Pavlov (1951f) wrote that as a youth he read Sechenov's (1863/1866) work *The Reflexes of the Brain* and that this work had profound, although not necessarily conscious, impact upon his subsequent work on conditional reflexes. Pavlov also added that Sechenov's concept of central inhibition had a powerful effect on European physiologists. It is possible that he had Heidenhain in mind.

Pavlov, thus, had access to both sources. Considering this issue from the historical point of view, it is most likely that Pavlov's initial knowledge of inhibition stemmed from Sechenov's work, which he, perhaps, had read already in the 1860s, during his Riazan years. It is also possible, as Pavlov seems to imply, that he had forgotten about inhibition until, years later, he was reminded of it in Heidenhain's laboratory or by reading Heidenhain's 1880 work. Therefore, considering Pavlov's high regard for Heidenhain's scientific achievements, it is very likely that he incorporated inhibition into his developing theory of higher nervous reflexes under the more immediate influence of Heidenhain's thoughts.

Notes

1. Heidenhain failed to mention the automatic rhythm of the heart.
2. All translations from German and Russian are the author's.
3. I wish to thank J. R. Kuppers and P. A. Lamal for their suggestions and editorial assistance. My thanks go to the librarians A. D. Cobb and B. J. Lisenby for their help in providing source material.

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