



Time Transformation in the Sign System of the Conditioned Reflex

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Abstract

How is time transformed when signs appear? In the sign system of the conditioned reflex, the sign (conditioned stimulus) reverses, changes the direction of time, and overcomes its unidirectionality and irreversibility. In a sense, there is a “return” to the past in the form of the future when the sign is introduced. The sign serves as a “Time machine” of sorts. The mechanism of time transformation is possible because a mirror is embedded inside the sign, the surface of which represents the psychological present time. When past experience meets that surface in the present, it may be reflected in the form of a future event. In the course of reflection, time changes its direction: if earlier time flowed from the event (the cause), it subsequently flows to other events (the purpose). Previously inaccessible past experience is now projected into the present, “comes to life” in it and is transformed into the future. In humans, unlike in animals, signs of the second order appear. Inside the signs of the second order, a mirror is built in, and the experience of the past as a subject is reflected in the future form as an object. An individual has the opportunity to consider oneself externally as an object. It goes beyond the subjective form. Thus, secondary signs once again change time direction. Due to this phenomenon, time becomes doubly reversible: first it turns around in a conditioned stimulus, and then in a secondary sign.

Keywords Time transformations · Sign · Conditioned reflex · Psychological present time · Secondary sign

Introduction

In science fiction, the possibility of returning to the past in order to change events and thereby influence the present and the future has garnered widespread interest. If we proceed from the point of view of the irreversibility of physical time, then it

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is impossible to return to the past from an absolute point of view. However, living organisms have formed a mechanism that allows them to return to the past in peculiar forms. This mechanism is a sign system that addresses recurring events. In sign systems, a specific form of activity determination is realized through the appearance of the final cause in the form of a purpose. Nomura et al. (2019) characterize it as retrocausality (retrocausal scaffolding), where the cause is placed in the future. If the living organism anticipates future purpose (i.e., a prediction), then the expected future state becomes the cause of the current behavior. For example, a specific goal of a dragonfly would cause changes in its body structure. Here the direction of causality is reversed and is called reverse causality. In reverse causality, the organism deals with the wrong side of the stimulus, which becomes accessible in the presence of a sign. The future now determines semiotic processes. This way of determination is closely related to the new form of time. This form of time is described as E-series (Nomura et al., 2019).

The emergence of new forms of time in biosystems leads to the formulation of temporal transformations in sign systems. First, this forms the question of the influence of the future on semiosis, when the cause is placed in the future and begins to influence the present. For example, Deely (2015) views semiosis as an influence of the future. He draws on Peirce's notion that "thought is what it is, only by virtue of its addressing a future thought which is in its value as thought identical with it, though more developed" (Peirce, 1868: 157). Since thought is involved in semiosis, signs act as the influence of the future on the present, and the meaning of the past is formed under this influence (Deely, 2015). Deely (2015) gives an example in which one can proceed to visit a friend, without knowing the current state of that individual (for instance, he could have been killed three hours before the meeting). Magnus (2011) compares Uexküll's notion of regularities with time plans. When organs adapt to the body, there is always an influence of upcoming events on previous ones. The ultimate function determines the form of a particular organ (Magnus, 2011). The future is also here as the final state of inclusion in the current development of the organism.

Another issue of the biosemiotic discourse about temporal transformations is the emergence of the reversibility of time, a change in its direction. De Tienne (2015) points out that a dynamic object can act as both an effective and ultimate cause of sign processes. Time has different directions. In the traditional view, the arrow of time is directed from the past through the present to the future. In this case, the object acts as an effective cause. In another, opposite kind of time, the arrow is directed from the future through the present to the past and is associated with the object considered to be the final cause. There is a transfer of the future into the present, which is expressed as anticipation. Interpreting the second model of time requires understanding the teleological discourse of Peirce and Aristotle (De Tienne, 2015). In the second model of time, in which it changes direction, one can see the transformation of the effective cause into the final goal (the realization of reverse causality), which begins to determine the current behavior.

Obviously, these two issues (semiosis as the influence of the future and the change in the direction of time when signs appear) are closely related. The future begins to influence the present in a pre-formulated sign system, and is the result of a change in the direction of the arrow of time. However, the mere indication of a

change in the direction of time in sign activity is not enough to explain the essence of temporal transformations. It is necessary to take a closer look at the essence of this phenomenon, reveal its mediating mechanisms, explain the emergence of the mode of the future and concretely demonstrate temporal transformations using various examples of biosemiotic systems.

To answer these questions, the model of the conditioned reflex is used in this article. Using the example of a conditioned reflex, living organisms acquire the ability to overcome the unidirectionality of time, from a relative point of view, to return to the past, changing the events of the present and the future as a result of a sign (conditioned stimulus).

Conditioned Reflex: The Principle of Physiology and Behaviour

The end of the nineteenth century was a time of major scientific breakthrough research, especially in the field brain functioning and behaviour. Classical conditioning studies belong to this era.

Pavlov (1973) set the task of finding an elementary, physiological and mental phenomenon in brain activity. Such a phenomenon was a conditioned reflex. The field of knowledge that was previously the subject of psychology has now become the subject of accurate scientific analysis, namely, physiology. It turned out that the work of the digestive glands under the influence of mental stimuli, for example, the release of saliva at the sight of food, can be studied objectively. In addition, changing the conditions in the experiment led to changes in the activity of the digestive glands, which obeyed the laws of reflex. These new reflexes, in contrast to the previously known unconditioned reflexes, were called conditioned. They are conditional because they depend on certain conditions and require certain conditions for their formation (Pavlov, 1949).

Pavlov (1973) expanded the category of reflex, which led to the expansion of the subject of physiology: the transition from physiological research to behavioural research. Thus a new branch of physiology was founded, namely, the physiology of higher nervous activity. Lower nervous activity integrates and coordinates intraorganic processes. The higher nervous activity is the area of conditioned reflexes; it aims to interact with the surrounding world and performs a subtle and precise adaptation to the environment. Therefore, Pavlov (1973) called the conditioned reflex activity of the digestive glands “external”.

The integration of the reflex principle with the signalling principle is fundamentally important in Pavlov’s teaching. Signalling is a reflex (Pavlov, 1949). At the same time, numerous conditioned stimuli signal relatively few unconditioned stimuli. The organ of signalling activity is the large hemispheres. The experience of Goltz (1881) demonstrated that an animal is rendered disabled following removal of the large hemispheres and is doomed to death without the help of an experimenter. In this case, only close contact interactions are realized. When the signal function is deprived, the ability to navigate in a wide range of environmental conditions is lost.

The signal is adaptive in nature; it performs a preventive function: it prepares the animal’s body for meeting future events. Therefore, salivation already occurs at the

time of presentation of a signal, for example, a sound stimulus. By the time the food enters the mouth, the animal is already prepared for its assimilation.

According to Anokhin (1975), studies on conditioned reflexes made it possible to extend the category of the future to animal physiology, whereas previously the concept of the future was used mainly to describe human behaviour. “Adaptation to future events” and “anticipation of the future” was the property of humankind and was a sign of the most expedient brain processes. Formulating the conditioned reflex as a “warning” function, i.e., the function of adaptation to future events, Pavlov thereby introduced a third category of time into physiology – the future. From that point on, the future in the life of organisms had become the subject of the same objective scientific research as the other two categories of time (Anokhin, 1975: 251).

In defensive conditioned reflexes, signalling allows animals to hide from predators, thereby preserving their lives.

A strong animal uses a small, weak animal as food. The latter must cease to exist if it begins to defend itself only when the enemy touches it with teeth and claws. In addition, it is another thing if a defensive reaction occurs at the sight of an enemy from afar, at his sounds, etc. Then, a weak animal will be able to escape, hide, that is, survive (Pavlov, 1949: 32).

Surely, the experimental material obtained from Pavlov’s school expanded existing ideas about the nature of the conditioned reflex. At the same time, there were contradictions in the explanation of the basic mechanisms of nervous activity: Working hypotheses about the closure of the conditional connection were modified, and some were discarded and replaced with newer relevant hypotheses. Nevertheless, the conditioned reflex, as one of the main phenomena of the nervous activity of higher animals, retains its significance and can be used as a natural science model for studying sign systems.

Conditioned Reflex as a Sign System

One of the characteristics of a sign is its ability to act as a substitute for other phenomena or objects. Some experiments on conditioned reflexes demonstrated that an animal can gasp for air or lick a light bulb, and these stimuli may act as food substitutes. Therefore, the relationship between conditioned and unconditioned stimuli can be considered within the framework of sign activity. The conditioned stimulus (signal) acts as a sign, and the unconditioned stimulus acts as an object of designation.

Cassirer (1953), considering the symbolic behaviour of animals, cites the opinion of Wolfe (1936) regarding the presence of symbolic processes in primates, as well as the opinion of Yerkes (1943) and the possibility of detecting in animals the precursors of symbolic processes similar to humans. According to Wolfe (1936), animals respond to signs as a substitute for food as food itself. In addition, Cassirer (1953) also evaluated Pavlov’s experiments, pointing out that stimuli, such as a bell, can become a “sign for dinner”, and some animals may not show interest in the food prior to a sign.

Williams (1929) wrote that stimuli that cause preparatory reactions in an animal can be considered signs of conditioned reflex training in many cases. Tolman (1932, 1933) used the term Sign-Gestalt in relation to signalling activity, the implementation of which assumes the formation of a connection between the designated phenomena (signifiers) and signals. At the same time, an integral spatial configuration is formed for the animal that regulates behaviour.

A special analysis of the conditioned reflex as a sign system is carried out in the works of Shingarov (1978, 2008). In his opinion, the sign absorbs the unconditioned stimulus in an “idealized” form, and it causes the same reaction as the unconditioned stimulus itself. When the sign system of the conditioned reflex becomes established, the relations between the organism and the environment change. The unconditioned stimulus in the unconditional reflex serves to cause activity; in the conditioned reflex, the activity of the organism is directed at the unconditioned stimulus. The stimulus-cause evolves to a stimulus-purpose. This is clearly evidenced by the bilateral nature of conditioned connections.

The ability of a conditioned stimulus to directly evoke activity and refer to a specific object gives grounds to consider it as a kind of indexical sign. The assignment of conditioned stimuli to indices is noted in some work, for example, Kull (2018). A conditioned stimulus does not require a causal relation between objects, and the formation of a conditioned connection occurs through a mediator—the nervous system. In addition, the conditioned stimulus is directly determined by its object—the unconditioned stimulus that took place in past experience, and thus refers to the past. Additional data are needed to confidently classify conditioned stimuli as indices. Rather, we can talk about the predominance of indexality and the tendency to consider conditioned stimuli as indexes. Moreover, as Stjernfelt (2007) notes, the icon, index, and symbol are not separate classes of signs, but are components of sign activity. He notes that in Peirce’s doctrine: “The trichotomies record aspects of sign, not mutually exclusive, independent classes of signs: symbols and icons do not form opposed, autonomous sign classes; rather, the content of the symbol is constructed from indices and general icons” (Stjernfelt, 2007: 53).

A level of indexality is characteristic of the so-called natural conditioned stimuli. These include the appearance of food and animal sounds (for example, howling wolves). In natural conditioned reflexes, the signifier and the signified are closely related. What matters here is the physical proximity of the signifier and the signified. Conditioned reflexes with artificial stimuli, despite referring to the object, go beyond the natural fusion of signifier and signified. There is a kind of arbitrariness, the possibility of associating different signifiers with the same signified. And the signified itself has no relation to the signifier. For example, sound, before the creation of a conditioned reflex, had nothing to do with food. Connection becomes more flexible and arbitrary. Here a new rule is established linking the signifier to the signified, and the indexality is reduced.

The Concepts of “Stimulus”, “Signal” and “Sign” Provide Plasticity to Conditioned Reflex Activity

Reflex mechanisms are machine-like, they function within the framework of strict necessity. At the same time, the nervous system is extremely plastic and adaptive in relation to the environment. To a certain extent, it is expedient, a kind of “mind”: it combines necessity and freedom. Physiologists have long paid attention to this duality of the nervous system, in particular, Sechenov (1953) wrote:

A headless frog is suspended vertically. The skin of the belly is irritated by acid on one side of the body, for example, on the right. Under baseline conditions, the frog will rub the irritated place with its right hind limb, sometimes also with the front right limb, if the site of irritation lies close to the latter. But if the right hind limb of such a frog is cut off: then it will begin to rub the irritated site with its left hind limb, despite the fact that this movement is apparently awkward for the frog. Who, seeing such a phenomenon, will not say, in fact, that a kind of mind sits in the spinal cord of a frog? (Sechenov, 1953: 55).

The fact that the frog begins to rub the irritated site with the other limb shows the flexibility of the nervous system in the efferent, executive part. But the nervous system also becomes flexible in the afferent, sensitive part. This is evidenced by the experiments of Pavlov on digestion, which, were the foundation for the development of the doctrine of higher nervous activity, and for the understanding of the relationship between the concepts of stimulus and signal. Pavlov (1951) showed that digestion consists of two phases: mental and chemical. The significance of the mental phase can be demonstrated by the experiment of imaginary feeding (after esophagotomy) when, in the experimental animal, food enters only the oral cavity, but cannot enter the stomach (the presence of the food in the oral cavity is sufficient to elicit the function of the gastric glands). The act of feeding leads to the secretion of gastric juices, which is of great physiological importance. It has been shown that if food is put into the stomach without being perceived by the animal, then the food is digested very poorly, sometimes it even rots, acting as a direct stimulus. The initial “mental” phase is an important condition for launching the subsequent chemical phase of digestion. In this case, the stimulation of the gastric glands is caused not by the direct stimulus on them, but by the action of stimuli on the receptors in the oral cavity, chewing, as well as by a combination of visual, sound and other stimuli. This phenomenon demonstrates the shift of gastric gland stimulation to other, indirect stimuli, which begin to play the role of a signal.

Thus, the action of the stimulus is always confined to a specific receptor apparatus, and its transformation into a signal is associated with endowing it with a specific meaning.

In one example, the skin of dogs was irritated by an electric current, which caused a defensive reaction in the animal. Subsequently, electrical stimulation was coupled to food intake. As a result, there was no trace of the initial defensive

reaction, rather a typical food reaction arose: the dog runs to the feeder and saliva is released for food (Pavlov, 1973). This experiment demonstrates the discrepancy between the concepts of stimulus and signal and shows that the same stimulus can receive different signal values.

In the same time the same signal value can be embodied in different stimuli. So, a food signal can be a sound, visual or tactile cue or other stimulus (Pavlov, 1973).

Let us now consider the relationship between the concepts of “sign” and “signal” in the model of the conditioned reflex. The signal causes a direct physiological reaction, and the sign performs the function of designation, defining the architecture of activity and preparing the body for action. The classic experiment on conditioned reflexes, is the so-called short-delayed action of the conditioned stimulus, when the food is immediately presented after the signal is given (the signal and the food are not separated by a time interval). Here, the signal is presented at the same time as a sign. However, in the case of a delay, the action of the initial stimulus as a signal and food presentation are separated by a time interval (Pavlov, 1949). First a conditioned stimulus is presented, which lasts, for example, for three minutes, and only by the end of the third minute is reinforcement (food) given. The experimental delay consists of two parts: an inactive period during which inhibition develops (there is no reflex reaction) and an active one, when, by the time food is approached, the conditioned stimulus acquires its signal action. Thus, at first the stimulus appears only in the form of a sign, it determines the general vector of the eating behavioral act, and then, after the third minute, it acquires its signal value, realizing the performance part of the reflex—salivation. This allows the sign system to better adapt to the conditions and conserve energy resources. When a separate stimulus begins to designate a specific phenomenon and causes a certain physiological activity, then it is simultaneously a stimulus, a sign and a signal.

Thus, the function of the stimulus, signal and sign, their common and distinctive features, ensure the plasticity of conditioned reflex activity in its afferent and efferent parts.

Bidirectionality of Conditioned Connections

For a long time, researchers, including psychologists such as Ebbinghaus (1885), have paid attention to the bidirectionality of associative connections.

The idea that a conditioned reflex has two-way connections was demonstrated by Pavlov (1973). When a dog is trained to raise a paw and is then given food, the dog begins to raise its paw independently when it is hungry. Pavlov at that time suggested that flexion causes irritation of the kinesthetic cells of the cerebral cortex, which bind to the cells of auditory and food stimuli. In this system of cells, the excitation goes “back and forth”, precisely in opposite directions: from kinesthetic cells to food cells and, conversely, from food cells (with food excitation) to kinesthetic cells.

Ideas about backwards conditioned connections were developed by Pavlov’s students and followers (Asratyan, 1965, 1974, 1977; Dostalek, 1964; Kupalov, 1949; Skipin, 1947). According to Asratyan (1977), the bidirectionality of

conditioned connections is the most important physiological basis of goal-directed behaviour. In one of his experiments, at the moment of sound action, a dog was trained to press the pedal to get food. In the intervals between the action of the sound, the dogs were in close proximity to the pedal, as if waiting for the sound to occur. The experiment showed that the original direct connection (direct conditioned connection): pedal → real food, transformed into the opposite. If earlier the pedal had caused the appearance of food (the reason), the dog would direct its activity to the pedal (the purpose). The animal organism seems to then return to the beginning of activity—it moves along the backwards conditioned connection in the opposite direction (Asratyan, 1977).

In the experiment of Kupalov (1949), it was also demonstrated that after a dog ate food in response to a signal, it did not immediately run to the original square on the floor in the experiment, but rather rushed to the signal stimulus. A similar situation occurs when a food conditioned reflex was developed to light a lamp. After eating the food, the dog turned its head back to the lamp, although it was no longer lit. The dog tried to return to the lamp as a stimulus that had caused the appearance of food.

Due to backwards conditioned connections, the living being will return to the action of the past stimulus. However, the return is carried out as a goal, that is, as an event in the future. The transformation of a cause into a purpose reflects the transformation of time in a sign activity, namely, the transformation of past experience into future events. Let us consider the essence of these temporary transformations in the general philosophical context.

Transformations of Time Dimensions in the History of Philosophy

The content of mental experience can occur in different time dimensions: in the past, present or future, but the belonging to a certain time dimension can be transformed. This is important because the presence of an object of mental experience in a certain time dimension determines its existence and current state. The actual state of the object and the activity of the animal organism are directly related. The closer the object is to the present time, the more valid and relevant it is for the organism.

Transformation of time dimensions, namely, the transition of past experience into future events, can be found in the works of some thinkers. Augustine (2006) points out the important role of memory in the transformation of a single dimension into another. Memory is the past because memories are only about what happened. However, at the same time, in the future (in the waiting processes), memory also plays a role, since it is necessary to remember how the memory should end. Therefore, waiting for the future cannot happen without memory. If something is expected, for example, the end of an event, then it has already been established that this kind of ending occurred in the past. For cases of waiting, a kind of transformation of the experience of the past into the future takes place. The future is like a modified past, or a kind of memory of the future.

Hobbes writes about using the experience of the past to predict future events:

No man can have in his Mind an Idea of the future; for there is no future yet: but from our Ideas of the past we create the future; or rather, we call the past, the future is relative. Thus, after a Person has become accustomed to seeing similar preceding events follow similar consequences, whenever he sees that something similar happens to something that he has seen before, he looks that the same thing that followed should follow (Hobbes, 1840: 16).

Hobbes (1840) gives an example of a man who repeatedly observed how punishment follows the commission of a crime. Thus, when he saw a crime happening, he also expected that there would be a punishment for it. “But consequent unto that which is present, men call future; and thus we make remembrance to be the prevision of things to come, or expectation or presumption of the future” (Hobbes, 1840: 17). It should be emphasized that Hobbes (1840) associated transformations of the past into the future with signs: The previous event was a sign for the subsequent event.

Time Transformation in the Sign System of the Conditioned Reflex

The transformation of past experience into future events does not occur symmetrically. The living organism returns to the stimulus as a goal in a qualitatively new form. This plays an important role, as it allows biological systems to develop and not repeat what occurred in the past. From this point of view, living organisms, as a result of sign systems, change the past (in a relative sense) and thereby transform the present and the future. Past experience is “projected” into a future that is beneficial for living organisms by eliminating and taking into account the negative consequences and effects that have taken place. This can be demonstrated through the following examples.

In one of the experiments, electrical irritation of the vagus nerve in dogs led to short-term cardiac arrest of two to three seconds. The combination of the current with the signal caused the formation of a conditioned reflex with the opposite effect: blood pressure increased, and the heart rate increased (Voronin, 1965). This experience shows the difference between an unconditioned reflex and a conditioned reflex. The conditioned reflex takes into account the unfavourable “past” (in the form of cardiac arrest). Unfavourable past experience is eliminated by the opposite physiological activity in the form of increased cardiac activity to balance the functional state. Thus, a form of the future that is favourable for the living organism is projected into the future, or “turns around”.

In the Konorski experiment (Konorski, 1967), a solution of hydrochloric acid was injected into the oral cavity of a dog. The introduction of hydrochloric acid is accompanied by noise. As a result, a classic “acid” conditioned reflex is formed, in which the action of the noise signal causes salivation. In the further course of the experiment, the presentation of noise was combined with flexion of the limb, and acid was not poured at all. Thus, an instrumental conditioned reflex formed, in which the noise caused the movement of the paw every time. Salivation disappeared

completely at the same time. An important feature of this reflex was extraordinary resistance.

In this form of reflex, the acid itself was physically present only at the stage of reflex development, and in the future it was never presented at all. In other words, the physical interaction with the acid took place only when a conditioned connection was formed. Here, we can surmise that if a stimulus in the past was a stimulus – cause (a real acid), then in a conditioned reflex, the living organism returns to its opposite future form – the purpose (the absence of acid). In this future form, it becomes possible to avoid an unfavourable past event and to “walk away” from it.

The Role of the Psychological (Subjective) Present Tense in Temporal Transformations in the Sign System of the Conditioned Reflex

The sign in the sign system of the conditioned reflex allows you to return to the past stimulus as an event of the future. At the same time, for the transformation of past experience into a future goal, the mediating role of the subjective present time is necessary. Its importance in the processes of semiosis is emphasized (Kull, 2018). Let us review the role of the psychological present tense in temporal transformations. The “return to the past” becomes possible thanks to the creation of the format of the psychological present tense within the sign. The psychological present mediates the transition of past experience into future events.

There is reason to believe that the significance of the psychological presence for sign activity is connected with the peculiarity of its nature. Physical time can be considered a line, a one-dimensional formation. At the same time, the present time is only a brief, barely perceptible moment, the boundary between the past and the future. The subjective (mental) present tense, in contrast to physical time, is an integral range of a certain duration, which includes both a portion of the past and the future. For example, part of today has already passed, and part has not yet come, but both parts belong to a single present time. If such a time is placed in a coordinate system, for example (X, Y), it consists of two dimensions: On the abscissa axis, parts of time are in relation to sequence, and on the ordinate axis they are in relation to simultaneity. If we add a third Z-axis, we obtain a duration measurement. Many philosophers and linguists have pointed out this nature of the subjective (mental) present. This nature underlies the reversibility of processes. For example, you can say: “He will come now, because he will come to-day; he has come now, because he came to-day” (Aristotle, 1991: 75). This is not possible for the past. You can say that he came yesterday, but you cannot say that he will come yesterday. This is because there is no correlation of the particles of the past and the future.

Bergson writes about the peculiarity of the psychological present tense:

What I call ‘my present’ has one foot in my past, and the other in my future. In my past, firstly, because ‘the moment at which I speak is already far away from me’; in my future, secondly, because this moment is approaching the future: I am striving for the future, and if I could fix this indivisible present, this infinitesimal element of the time curve, this direction of the future that it

would indicate. Thus, the mental state, which I call my present, ‘must be both the perception of the immediate past and the determination of the immediate future (Bergson, 1929: 177).

Husserl (1964) points out that if the intention is directed to a particular tone of the melody, then a tone just sounded will be considered to have already passed. If the intention covers the entire melody as a whole, then even the tones that have just sounded will be considered in the present tense in a single connection of grasping. Whitrow (1980) uses the metaphor of a moving line to describe the mental present, in which some states replace others but are simultaneously held together. Guillaume (1992) believes that the grammatical present tense always carries particles of the past and the future, which are called chronotypes.

Vekker (2000) writes that in physical time, events either follow each other or are presented simultaneously. Thus, the sequence characteristic excludes the simultaneity characteristic. The psychological present is paradoxical: it combines these characteristics. Therefore, mental time acquires the property of reversibility: you can go from the end of the time series to its beginning.

According to Titchener, mental time is represented by two dimensions: “It seems that psychological time is rather a surface, a two-dimensional variety, and that its two dimensions are simultaneity and sequence” (Titchener, 1928: 340).

The “psychological present” corresponds to the phenomenal present in biosemiotics. As Kull points out: “From a phenomenological point of view, the perceived time has a certain finite interval which is interpreted as present” (Kull, 2015: 226). The phenomenal present has dimensions in itself: a combination of succession and simultaneity. In the phenomenal present, there are simultaneously several possibilities, several modes of action. The conflict of operations in decision making is possible precisely because of several coexisting options. As a result, their incompatibility is achieved. It is this incompatibility of operations (or codes) that makes semiosis itself possible.

What is the significance of the mental present for the sign system of the conditioned reflex? When the sign is a conditioned stimulus (for example, a metronome), it causes food salivation; then, the situation in itself is somewhat paradoxical. The fact is that from a physiological point of view, there is no adequate genetically determined food stimulus here. At the same time, it is an act of perception, but what is perceived, in fact, is that which no longer exists, and at the same time, that which has not yet arisen. Food was in the past and will only appear in the future. At the same time, the perception of a conditioned stimulus causes a reflex reaction that is not inferior to the reactions caused by the perception of real food. Since the actual food itself acted in the past, only this “past” food is capable of causing the reflexogenic activity of the sign-conditioned stimulus. Past food must now, on certain grounds, organize a new behaviour aimed at achieving the future. However, how can an “absent” stimulus act, something that is not there now, but only was in the past? This is possible precisely because past experience is included in the psychological present as a part of it, as it has the ability to cause activity.

This aspect of temporal transformations indicates the need to embody past experience in the present tense. What can be the life force of the present time? At its

core, the present tense is associated with the organization of action. The following quote from Bergson may help to better understand this idea: “My present is that which interests me, which lives for me, and, in a word, that which summons me to action; where my past is essentially powerless” (Bergson, 1929: 176). This philosopher, characterizing memory and perception, makes a distinction between them in essence and not in degree. For a memory to become active, it must pass into the plane of the present tense. The memory itself cannot act as a past, but it could act by investing itself in the present sensation, borrowing its vitality from it. The psychological present, according to Bergson (1929), constantly “raises” the past to the level of the present and continues it into an action that determines the events of the future. The more that past experience is learned and translated into the present, the more free the future becomes. The living organism no longer repeats the past.

Bergson (1929) explains his ideas in the form of a cone metaphor. The base of the cone is in the past, and its tip is in the plane of the present – in the plane of perception and action. The cone is constantly growing due to the increase in volume. For the past to cause action, it needs to be projected into the plane of the present to the tip, borrowing its vitality from it.

Giving his metaphor of the cone, Bergson reveals the essence of the functioning of the sign. In a conditioned stimulus, for example, a past acid acts on the animal, it is perceived and causes the action as a real stimulus (saliva is released, a paw rises, etc.). The memory of acid acquires the character of acid perception. If in the presign reality events constantly leave the plane of the present time, then in the sign activity, the experience of the past returns to the plane of the present. That is, the time flows in the presign and sign reality are opposite to each other. At the same time, getting into the plane of the present time, past experience seems to be reflected from this surface in the form of future events. Thus, the plane of the present can be represented as a mirror surface. The present tense is like a reflective surface on which the transformations of time themselves are realized. The present acts as a universal hinge that “turns” time dimensions.

Reflection in a Mirror is a Metaphor for Temporary Transformations in the Sign System of a Conditioned Reflex

The return to the past stimulus as a future purpose can be represented as a mirror image. Let us imagine that an unconditioned stimulus is an object that has two sides. However, only one of its sides is active, that is able to act on us (as the cause). When the object is turned to us by the opposite side, it is no longer able to act. In this case, it is only a memory of the past. We find ourselves outside the sphere of the causative action and, thereby, lose contact with it.

However, if we wanted to return to the active side of the object, we would need to go around this object and look at it from the back side. However, this is impossible as it would mean a real return to the past. We also need to see the active side of the object when it is facing us with its opposite side. This opportunity is given by signs. If you put a mirror in front of the object, the active side will be reflected in it, and we will see this reflection. However, the mirror image of the active side does

not appear in a direct form but in an inverted form. This reversed form, which we see in the mirror, is the purpose. The mirror surface in this metaphor is the psychological present tense. Past experience comes to life in this present and appears for us already in the form of the future. Thus, due to the sign, we can look at the object as if from the opposite—wrong side. We turn the closed inaccessible past form of the object into a form of the purpose that is accessible to us. Therefore, the sign shines with a reflected light: we perceive the experience of the past, which, reflecting from the mirror surface, changes direction and appears to us in the form of the future. Time, in a relative sense, becomes reversible. Previously, time moved away from the object, but now we are moving towards the object. In a certain sense, we can talk about two axes of time: the first axis of absolute time always retains its direction, and the second axis—the axis of relative mental time changes its direction. This axis seems to form a new time contour, which is included in the absolute time axis. These reversible time circuits enrich the behaviour of living beings, due to which biological systems are constantly evolving (see Fig. 1).

In the presign reality, a living organism is located after the action of the stimulus (the cause); in the sign reality, it is located “higher” along the flow of time until the moment of real action and directs activity to the stimulus as a purpose.

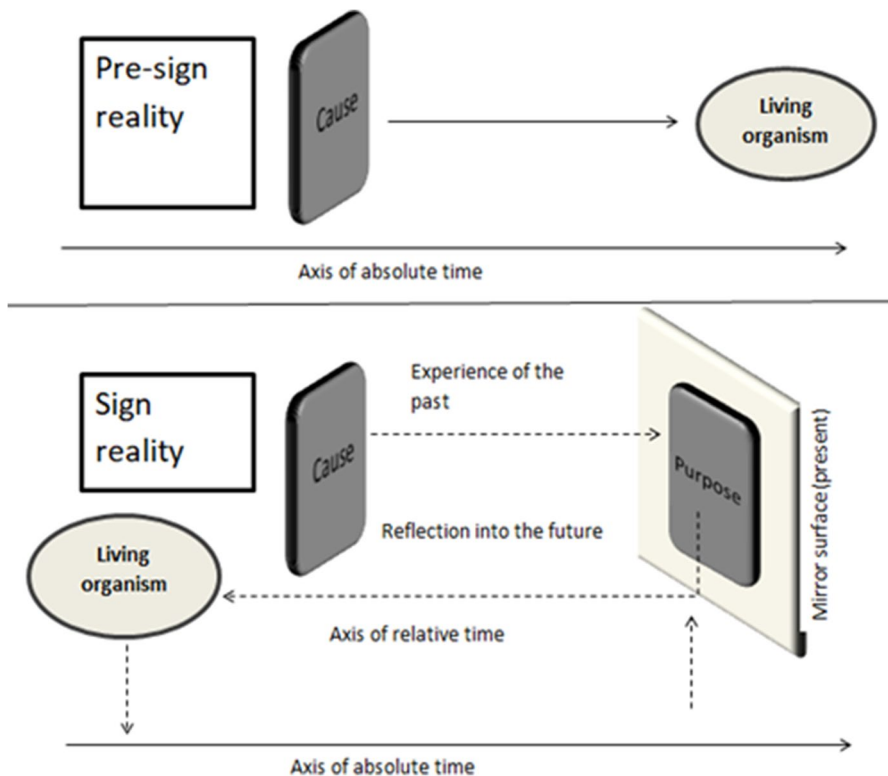


Fig. 1 The metaphor of time transformations in the sign system of the conditioned reflex

It is impossible to return to the cause, that is, to the past, due to the irreversibility of the axis of absolute time. However, this return is possible in the relative axis of psychological time (where repeated events take place), with the appearance of the purpose form.

Conditioned Reflexes and Purposeful Actions

The considered features of the conditioned reflex function belong to the field of automated mechanisms. What are differences between the reactions of the reflex and the purposeful behavior of a person?

Signs function in conditioned reflexes—conditioned stimuli. Despite the flexibility of the nervous system in its afferent and efferent parts, conditioned reactions proceed in a machine-like manner, in which perception and movement are closely linked. In humans, a new intermediate link appears between perception and action, which is the secondary sign. According to Vygotsky (1984), the secondary sign is embedded between perception and action and forms a functional barrier. Thus, the fusion of the sensory and motor fields is overcome.

New sign systems emerging in humans reflect the function of second-order stimuli. Pavlov (1973) considered two signaling systems. If sensations and ideas are the first signals, then speech acts as signal signals.

The inclusion of secondary signs in human behavior, the second signal system, leads to the opening of the initial fusion of the conditioned reflex. As a result, the activity of a living organism becomes more complicated. According to Vygotsky (2005), this consists of two stages in a person's voluntary action. The first stage is the decision-making stage, and the second is the performing stage. At the stage of decision-making, there is a conflict of various motives. For example, when a person needs to get out of bed, the first motive is the desire to get up, the second motive is the reluctance to get up. To resolve the conflict, a person begins to count to himself and stands up at the count of three.

Thus, he introduces an additional tool that acts as a conditional signal:

In the example of getting up, I got up at the signal “three” (conditioned reflex), but I, myself, through a signal and a connection with it, got up, that is, I controlled my behavior through an auxiliary stimulus or an auxiliary motive. We find the mechanism itself, that is, controlling oneself through auxiliary stimuli, in experimental and clinical studies of the will (Vygotsky, 2005: 497).

Introduction of an additional means for decision-making leads to the second, performing stage. For example, after the intention to drop a letter in the mailbox has been accepted, the process will be carried out automatically through a conditioned reflex: “The second, relatively independent part of the voluntary process acts exactly as the selection reaction usually acts. Here we have the Pavlovian conditioned reflex” (Vygotsky, 2005: 500).

The first stage, therefore, has a kind of freedom of decision-making, and the second one is realized in a conditionally reflex way. The first stage is related to abductive inference. As Kull (2015) suggests, at this stage there is an incompatibility of

several options. Through the phenomenal present time, there is a transition to the second—the performing part of the behavioral act. The transition from afferent synthesis to decision-making reflects the choice of one of the many possible behaviors to achieve the goal (Labra-Spröhnle, 2016). The means of transition to the next stage, the stage of deduction, is a secondary sign. This process is reminiscent of a logical process, and Pavlov wrote that the mechanism of the conditioned reflex function corresponds to the mechanism of unconscious inference (Pavlov, 1973).

The second, the performing stage, is associated with the formation of a habit. “It is formed exactly as habit is formed, that is, it consists of constructing a conditioned reflex curve” (Vygotsky, 2005: 499). Meanwhile, new relationships and, new rules are formed. Due to these rules, the uncertainty of interpretations is eliminated, and the behavior itself becomes directed. From this point of view, the conditioned reflex is a kind of habit.

Closely related is the question of the participation of various forms of memory in conditioned reflexes. Separate experiments have shown that conditioned reflexes are especially stable and rely on very ancient forms of memory. Prior work on memory processes established that dogs retain the ability for conditioned reflexes even when the neocortex is removed (Beritashvili, 1974). However, further studies are needed for a definitive statement that only non-declarative memory plays a role in the conditioned reflex.

In the conditioned reflex there is, albeit in a weak form, an interpretative dimension. From prior work, it is well known that in addition to the signal itself, the context as well as the conditioned stimuli that accompany or precede the signal, play an important role. This is the so-called situational afferentation (Anokhin, 1975): the same signal in different situations can cause different reactions. The possibility of changing the signal value of the stimulus, the so-called conditioned reflex switching, has been shown experimentally (Asratyan, 1953). For example, the same conditioned stimulus (tone) in the same animal evokes a food reflex in one case, and a defensive reflex in another. The food reflex occurs when a signal is presented by one person, and the defensive reflex occurs when the same signal is presented by another person. The person himself—the experimenter acts as a switch. At the same time, the animal, being in the experimental environment before the action of the direct signal, is not passive. It “waits” for specific stimuli that are associated with the action of the switch. One can say that this switching stimulus creates a background for the main stimulus and is a kind of an interpretant, a sign that mediates the relationship between the main conditioned stimulus and the object. The interpretant, as it were, wedged into the linear nature of the flow of the conditioned reflex connection, and in this case “the logical interpreter may need some critical time to act” (Gorlée, 2016: 16). Such a situation demonstrates the function of the sign system. The isolated action of a signal can only be evaluated within the framework of this interaction. For example, a food signal has no meaning outside of the complete system that encompasses the initial need for food and its final satisfaction (Labra-Spröhnle, 2016).

The inclusion of second-order stimuli in the structure of behavior causes a radical restructuring of all human activity. The appearance of secondary signs does not consist only of their designation of primary signs. Vygotsky (1984) believes that if

the primary signs are directed at the object as a goal, then the second-order stimuli become directed at the person himself. Words as signs of the second order allow one to master one's own behavior and consider oneself, from the outside, as an object. "Between the object (attracting the child as its aim) and behavior, there appear stimuli of the second order, now directed not immediately at the object but at the organization and personal planning of the child's behavior" (Vygotsky, 1984: 36).

The process of subjectivity reduction that becomes possible with the advent of second-order stimuli, has an important consequence for behavior. If the animal only uses ready-made conditioned reflexes, then the person himself actively develops them. An animal, being in an experimental setting, is an object of study for a scientist. It uses various stimuli and turns them into conditioned signals. By itself, the animal is not able to create a stimulus, a sign, thereby overcomes the rigidity of the conditioned reflex. With the advent of secondary stimuli, a person considers himself from the outside, as an object. In a way, he acts as an experimenter on himself and creates new conditioned reflexes. "In brief, we might say that this is an artificially created reflex" (Vygotsky, 2005: 499). For example, when the subject is in an empty room, she has a conflict of motives: to leave or stay.

To overcome this situation, she creates a new stimulus using a watch. Vygotsky writes:

The subject decides "When the hands of the watch reach a certain position, I will get up and leave." consequent, she closes a conditioned connection between the position of the hands and her leaving; she decides to leave through the hands of the watch and she acts in response to external stimuli, in other words, she introduces an auxiliary motive similar to the dice or the count "one, two, three" for getting up. In this example, it is very easy to see how a change in the functional role of the stimulus, its conversion to an auxiliary motive, occurs (Vygotsky, 2005: 498).

Vygotsky (1984) also draws attention to the change in function of speech. An important aspect here is the change of time. First, the action acts as a cause: it causes certain changes, including the verbal formulation of the results of this action. Speech only follows action. For example, a child draws something and only then formulates the theme of the drawing in words. Speech is subordinated to, and called forth by, action. Further there is a temporary shift of speech in relation to action: speech is shifted to the beginning of the action. It acquires a plan that anticipates and directs the action. The child has ideas about the future. "Planning its behavior, mobilizing and summarizing its past experience for the organization of its future action, the child passes over to active operations drawn out in time" (Vygotsky, 1984: 36).

Reflection in a Mirror as a Metaphor for Temporal Transformations in the Function of Second-Order Signs

In the mirror metaphor above, the stimulus was at the center of consideration. The return to the stimulus as a goal characterizes the phenomenon of reverse causality. What happens when signs of the second order appear? If in the sign reality of the

first order the organism acted as a subject causing a certain action, then due to signs of the second order there is a return to itself as an object. A kind of mirror appears, in which the subject sees his reflection as an object. In this reflection, the organism returns to itself in the form of a purpose. The past experience, in which the organism acted as a subject (cause), falls on the mirror surface of the mental present secondary sign and acts as an object—a purpose (see Fig. 2).

Now the organism changes its coordinates. Time here also changes direction. There is a “return” to the past in the form of a purpose. However, the reflection of past experience here takes place within the framework of the previously transformed system. Thus, time changes its direction twice: first due to the sign in the conditioned reflex, and then due to the secondary sign. In the secondary sign, we are “moving backwards” in time, which has already changed its direction due to the primary sign. This results in a reversed time loop inside a reversed time loop. This second temporal circuit makes it possible to interrupt the rigid conditioned reflex.

Levels of Anticipatory Systems of Living Organisms

According to Rosen (2012), most of the behavior that we observe in the biological realm, is anticipatory rather than reactive. He formulated the idea of anticipatory systems: “A system containing a predictive model of itself and/or of its environment, which allows it to change state at an instant in accord with the model’s predictions pertaining to a later instant” (Rosen, 2012: 313). In anticipatory systems, there is a natural system and a predictive model that provides information about future states.

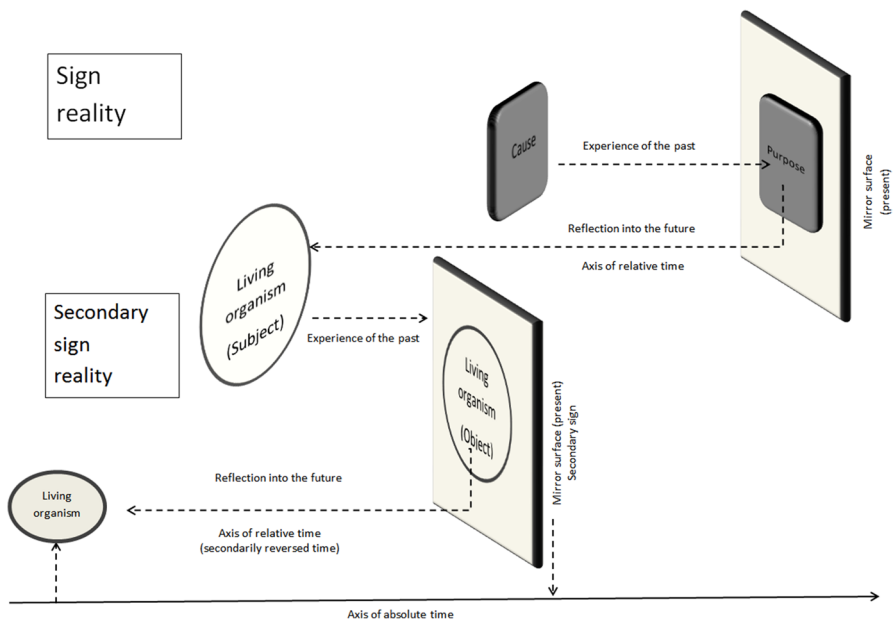


Fig. 2 The metaphor of time transformations in the function of signs of the second order

One example of a simple anticipatory system is the direct activation of a substrate and a catalyst in biochemical reactions. The initial substrate and its interactions with the enzyme, determine the subsequent state of the modified substrate. Thus, it acts not only as a substratum, but also as a predictor of the subsequent values of the system. Its role is essentially symbolic. At the same time, the maintenance of homeostasis occurs in the absence of feedback. Here, there is no mechanism that allows the system to “see” the value of the quantity that is being controlled. In addition, the time interval during which adaptation is maintained is limited (Rosen, 2012). There is no return to past states yet.

The conditioned reflex is mediated through the nervous system, so the processes of memory and prediction are improved. As discussed above, due to the specific sign in the conditioned reflex, time moves as if backwards and retrocausality is realized. But at the same time, the organism itself remains in the present. Only the object, the unconditioned stimulus, undergoes temporal transformations.

At the next stage, with the advent of voluntary regulation, turning oneself into an object allows one to come to the concept of the past and the future used by people. The subject itself becomes detached from the fixed coordinate of the present. It now becomes possible to mentally place yourself in the past, or refer to the future. Not only is the stimulus transformed in time, but also the subject itself.

Conclusion

The conditioned reflex allows us to show how the sign transforms time. There is a change in the direction of time. The animal organism “returns” to the past in the form of future events. There is a transformation of past experience into future events. If in the presign reality the organism is in the sphere of action of the stimulus (the cause), then the sign the organism directs its activity to the stimulus as a purpose without being directly under its action. The animal’s reaction is triggered in advance until the moment of the stimulus action. Thus, the preventive function of the sign is realized, and it prepares for future events. An important role in this is played by the mental present. What is perceived by an animal in a conditioned stimulus (sign) is a kind of mirror reality, the reality of reflected time. Past experience comes to the surface of the psychological present and is reflected in the events of the future. Thus, when an animal perceives a sign, it is turned towards the mirror (and not towards the real stimulus), and time (its relative axis), reflecting from this mirror, changes direction to the opposite. Due to the signs of the second order, the living organism now considers itself as an object: on the mirror surface of the secondary sign, the past experience of the organism as a subject is reflected onto the future form of the object. Time becomes, as it were, doubly reversible: the first time in a conditioned reflex, and then once again changes direction due to signs of the second order.

Thus, the contribution to the solution of biosemiotic questions about the influence of the future on semiosis and changing the direction of the arrow of time lies in the fact that the emergence of the relative reversibility of time is concretely demonstrated on the model of the conditioned reflex. This shows how the future target

form of the stimulus is formed, and the mediating role of mental present time is established.

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References

- Anokhin, P. K. (1975). *Essays on the physiology of functional systems*. Medicine.
- Aristotle. (1991). *Complete works*. Princeton University Press.
- Asratyan, E. A. (1953). *Physiology of the central nervous system (Scientific works)*. Publishing house of the Academy of Medical Sciences of the USSR.
- Asratyan, E. A. (1965). *Compensatory adaptations, reflex activity and the brain*. Pergamon Press.
- Asratyan, E. A. (1974). Conditional reflex theory and motivational behavior. *Acta Neurobiologiae Experimentalis*, 34(1), 15–31.
- Asratyan, E. A. (1977). *Essays on the physiology of higher nervous activity (in Russian)*. Press.
- Augustine. (2006). *Confessions*. Hackett Pub. Co.
- Bergson, H. (1929). *Matter and Memory*. George Allen & Unwin Ltd, The Macmillan Company.
- Beritashvili, I. S. (1974). *Vertebrate Animal Memory*. Nauka.
- Cassirer, E. (1953). *An Essay on Man*. Garden City. Doubleday.
- De Tienne, A. (2015). The flow of time and the flow of signs: A basis for Peirce's cosmo-semiotics. *The American Journal of Semiotics*, 1–2(31), 29–53.
- Deely, J. (2015). From Semiosis to Semioethics. In P. Trifonas (Ed.), *International handbook of semiotics*. Springer. https://doi.org/10.1007/978-94-017-9404-6_36
- Dostalek, C. (1964). *Rückläufige bedingte Verbindungen*. Verlag der Tschechoslovakischen Akademie der Wissenschaften.
- Ebbinghaus, H. (1885). *Über das gedächtnis: Untersuchungen zur experimentellen psychologie*. Duncker & Humblot.
- Goltz, F. (1881). *Ueber die verrichtungen des grosshirns: Gesammelte abhandlungen*. Universitaets-Buchdruckerei von Carl Georgi in Bohn.
- Gorlée, D. L. (2016). On habit: Peirce's story and history. In D. West & M. Anderson (Eds.), *Consensus on Peirce's concept of habit: Before and beyond consciousness* (pp. 315–340). Springer-Verlag.
- Guillaume, G. (1992). *Principles of theoretical linguistics (in Russian)*. Progress.
- Hobbes, T. (1840). *The English works of Thomas Hobbes Vol IV John Bohn*. Osmania University.
- Husserl, E. (1964). *On the phenomenology of the consciousness of internal time*. Indiana University Press.
- Konorski, J. (1967). *Integrative activity of the brain*. University of Chicago Press.
- Kull, K. (2015). Evolution, choice, and scaffolding: Semiosis is changing its own building. *Biosemiotics*, 8, 223–234.
- Kull, K. (2018). On the logic of animal umwelten: The animal subjective present and zoosemiotics of choice and learning. In *Semiotics of animals in culture* (pp. 135–148). Springer.
- Kupalov, P. S. (1949). On the mechanism of the conditioned excitation process (in Russian). *Fiziologicheskii Zhurnal SSSR Imeni IM Sechenov*, 35, 582–586.
- Labra-Spröhnle, F. (2016). Human, all too human: Euclidean and multifractal analysis in an experimental diagrammatic model of thinking. In Mihai Nadin (Ed.), *Anticipation across disciplines* (pp. 105–136). Springer.
- Magnus, R. (2011). Time-plans of the organisms: Jakob von Uexküll's explorations into the temporal constitution of living beings. *Sign Systems Studies*, 39(2/4), 37–57.
- Nomura, N., Matsuno, K., & Muranaka, T. (2019). How does time flow in living systems? Retrocausal scaffolding and e-series time. *Biosemiotics*, 12, 267–287.
- Pavlov, I. P. (1949). *Lectures on the work of the cerebral hemisphere*. USSR Academy of Sciences.
- Pavlov, I. P. (1951). *Lectures on the work of the main digestive glands*. USSR Academy of Sciences.

- Pavlov, I. P. (1973). *Twenty-five years of objective study of the higher nervous activity (behaviour) of animals*. Nauka.
- Peirce, C. S. (1868). Some Consequences Of Four Incapacities. *The Journal of Speculative Philosophy*, 2(3), 140–157.
- Rosen, R. (2012). *Anticipatory systems: Philosophical, mathematical & methodological foundations*. Springer.
- Sechenov, I. M. (1953). *Selected works (in Russian)*. Uchpedgiz.
- Shingarov, G. H. (1978). *The Conditioned reflex and the problem of sign and meaning (in Russian)*. Nauka.
- Shingarov, G. K. (2008). Pavlovsky conditioned reflex-natural science model for the study of sign systems. *Epistemology & Philosophy of Science*, 18(4), 145–163. <https://doi.org/10.5840/eps200818413>
- Skipin G. V. (1947). *On the mechanism of formation of the alimentary conditioned reflexes (in Russian)*. Soviet Sci.
- Stjernfelt, F. (2007). *Diagrammatology: An investigation on the borderlines of phenomenology, ontology and semiotics*. Springer.
- Titchener, E. B. (1928). *A text-book of psychology*. The Macmillan Company.
- Tolman, E. C. (1932). *Purposive behavior in animals and man*. Century.
- Tolman, E. C. (1933). Sign-Gestalt or conditioned reflex. *Psychological Review*, 40(3), 246–255. <https://doi.org/10.1037/h0071472>
- Vekker, L. M. (2000). *Psyche and reality: A uniform theory of psychological processes*. Smysl.
- Voronin, L. G. (1965). *A course of lectures on the physiology of higher nervous activity*. High School.
- Vygotsky, L.S. (1984). *Collected Works: In 6 volumes. Vol. 6. Tool and symbol in child development*. Pedagogy
- Vygotsky, L.S. (2005). The history of the development of higher mental functions (in Russian), In *Psychology of human development (in Russian)*, Meaning, Eksmo.
- Whitrow, G. J. (1980). *The natural philosophy of time*. Thomas Nelson and Sons Ltd.
- Williams, K. A. (1929). The conditioned reflex and the sign function in learning. *Psychological Review*, 36(6), 481–497. <https://doi.org/10.1037/h0074200>
- Wolfe, J. B. (1936). Effectiveness of token rewards for chimpanzees. *Comparative Psychology Monographs*, 12, 1–72.
- Yerkes, P. M. (1943). *Chimpanzees: A laboratory colony*. Yale University Press.

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