

Physiology and behavioral Science in Gaetano Martino:
Reflections on a physiologist's endeavor to discover the mind

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Abstract: This article aims to underline the organic way of working of an eclectic scientist and politician by the name of Gaetano Martino and his studies on nutrition, experimental reflex epilepsy and conditioned reflexes. The studies on conditioned reflexes were analyzing by Martino because he did not fully agree with Pavlov's ideas regarding the modifications of the reflex arc subsequent to the formation of a conditioned reflex.

Furthermore, thanks to his studies on conditioned reflexes, psychology and psychiatry have found, and continue to find, important developments towards the understanding of man's personality. The Messines physiologist, by virtue of his indisputable dedication and passion for research, managed to open a prolific dialogue between two apparently distinct and distant disciplines, actively moving towards an interdisciplinary approach, thus anticipating a basic principle of present-day science.

Keywords: Gaetano Martino, Ivan Pavlov, conditioned reflexes, classical conditioning, psychology, nutrition, psychiatry, experimental reflex epilepsy.

Introduction

In the past century, psychological and medical disciplines have become progressively more specialized and, thanks to interdisciplinary approaches, they currently work together actively and in total synergy in order to promote the advancement of knowledge. The interdisciplinary approach is an immensely valuable interaction that has become one of science's strongpoints. Since the beginning of the twentieth century, methods of interdisciplinary research can be found in the organic way of working of an eclectic scientist and politician by the name of Gaetano Martino. Through his research in the physiological field, he helped disciplines such as clinical psychology and psychiatry to understand the physiological and psychological functioning of the nervous system

Gaetano Martino: Biography

Gaetano Martino was born in Messina on November 25, 1900. He was a staunch anti-fascist man, endorsing liberalism since the days of the March on Rome. He studied medicine in Rome, where he graduated with honors in clinical surgery with a thesis concerning bone grafts on July 10, 1923. In 1925 Martino, after studying in many foreign cities including Berlin, London, Frankfurt and Paris, began his academic career at the Institute of Human Physiology at the University of Messina, which was led at the time by Joseph Amantea. Martino became a collaborator of the latter in 1925 and together they worked assiduously until 1930, when Martino was called as a lecturer at the Universidad Nacional de Asunción in Paraguay.

Here he directed the institute of human physiology giving proof of his noteworthy capacities as a researcher and teacher. He also served as a doctor in clinical departments struck by health emergencies caused by the war between Paraguay and Bolivia. On his return to Italy, he won the title of chair of physiology in Sassari and in November of 1934 he became professor of biological chemistry at the University of Messina.

On March 20, 1935, he was appointed chair of experimental physiology and subsequently, in 1936, as chair of human physiology at the University of Messina.

It should be noted that Martino was a strong supporter of applied research. Driven by his passion for teaching, he believed that research was imperative for the personal and professional growth of youth, as well as for the evolution of the human condition (Ferlazzo, 2002a).

After the Anglo-American landing in Sicily, in recognition of his academic qualities and his unwillingness to compromise with the regime, Martino was appointed head of the board of education and in 1944 rector pro tempore of the University of Messina until 1957, when he moved to the Faculty of Medicine at the University of Rome as chair of the physiology department.

Gaetano Martino was a remarkable intellectual of his time who managed to be both a politician and a scientist. He was a man of great intelligence and intuition, rigorous, but always ready to help his students, attentive and politically active (Ferlazzo, 2002b).

Gaetano Martino's entry into politics was propelled by the affectionate encouragement of Paratore and Orlando. His adherence to liberalism derived from his belief that a renewed Liberal Party would constitute an important and necessary balancing factor in society by attracting the middle class. Ever since July 19, 1949, the date of his first speech on the policy statements of the second De Gasperi government, Martino, in homage to a liberal organizational conception of the State, declared himself opposed to the delegation of legislative power to the government in the simultaneous presence of an assembly that was freely elected by the people.

Another issue Martino was passionate about regarded the importance of higher education: he immediately declared the university of Messina as an autonomous entity, conceived not only as a breeder of professionals, but also as a place that favored the individual growth of its students.

In February of 1954, as part of the neocentric party, Gaetano Martino sustained his first government occupation as Minister of Education in the cabinet of Scelba. The key points of the program he proposed were aimed to improve school buildings, to encourage a professionally-oriented education and to reform state exams, taking into account the profound transformation that the educational system had encountered after the war. His ideas invoked specific interventions for the University's general and, above all, moral requalification.

Following the resignation of Attilio Piccioni in September of 1954, Martino was interested in Foreign Affairs primarily due to his commitment to European integration: his action aimed to strengthen the Atlantic unity, always remaining in the wake of De Gasperi's atlanticism policy.

During his term in Foreign Affairs, Martino's efforts included designating Italy to administer Zone A of the free territory of Trieste, Italy's admittance to the United Nations (UN, December 1955), and negotiating for the London and Paris conferences in autumn of 1954 to institute the Western European Union (WEU), of which he was a firm supporter.

Subsequently, Martino pledged to re-launch the European Coal and Steel Community (CZEC) and worked towards the establishment of a common institutional apparatus that could serve as the political basis of economic integration. He was also the president of the European Parliament from 1962 to 1964, the head of the Italian delegation to the fifteenth and sixteenth sessions of the General Assembly of the UN and the President of the Italian delegation in the Ten Nation Committee on Disarmament conference.

Gaetano Martino died in Rome on July 29, 1967.

Nutritional Studies

Gaetano Martino was active in the field of research, and after graduating he focused primarily on the science of nutrition and physiology.

In 1926 he published a paper on the effects of inanition on the sexual characteristics of the rooster: In this study he employed the experimental method of re-feeding the roosters subsequent to a prolonged period of fasting. Through this study he showed how the animals subjected to the experiment resumed body weight and vital functions, with the aim of obtaining the essential nutritional factors. This initial study prompted Martino's interest, leading him to commence another series of studies regarding postprandial blood glucose digestion in dogs under fasting conditions.

In 1927 these studies enabled him to discover that the pancreas accumulated a hyperglycemic substance.

Martino noted that this hyperglycemic substance, accumulated with fasting, was excreted in relation to particular metabolic aspects and, furthermore, that it played an active role in inducing hypoglycemia once extracted in small quantities.

He came to believe that this hyperglycemic substance was a hormone because its physiological role was essential for correct vital functioning.

Unfortunately, this research was never continued in his Messina laboratory because similar research was being conducted in Germany, through which the term glucagon was coined to indicate the peptide hormone secreted by the pancreas.

Martino's studies caused a great uproar because they were conducted only a few years after 1923, when the Nobel Prize for the discovery of insulin was given to Frederick Banting and Charles Herbert Best (Zarate Arellano, 2002a).

Later, he devoted himself to another line of research in nutrition, that of the re-feeding of human populations; its purpose was to identify the nutrients that allow an easier and faster recovery of bodily functions and body weight. Thus he tried to find what is currently defined as an optimized or balanced diet.

His research thus turned its attention to the variety of food. He noticed how diets comprised of a scarce variety of food were wrong and harmful for one's health.

He employed a methodology that consisted in keeping the animal on an empty stomach and then re-feeding it exclusively through a few chosen foods; the most widely used and studied by him were milk and rice.

A result that emerged fairly quickly was that through this kind of reduced re-feeding technique there was a major shortage of B-complex vitamins.

Martino focused his attention on the essential importance of vitamins both for the animal and the human body. He studied, in fact, not only the phenomena of general vitamin deficiency, but also cases of hypovitaminosis and hypervitaminosis.

In addition to his studies on B-complex vitamin deficiency, Martino conducted numerous studies on vitamin E (1934a), which is a fat-soluble vitamin also called "antisteril".

He observed that a deficiency of vitamin E created through a synthetic diet throughout their growth, led rats to develop normal sexual organs that appeared to mature correctly but later proved to be defective in their reproductive functions.

In female rats placental alterations during pregnancy caused the death of the fetus and its subsequent reabsorption in the uterus, while male rats developed regressive alterations of the testicles with azoospermia.

However, sexual activity was preserved and it was not affected in either sex. The rats, in fact, continued to mate without reproducing.

On the basis of research conducted on chickens by Martino, Fulchignoni and Alibrandi (1934b), Vitamin E was defined as an essential vitamin for sexual development.

Gaetano Martino, therefore, made some noteworthy contributions to science; indeed, he was a prominent researcher and founder of what is currently known as Nutritional Science (Zarante Arellano, 2002b).

Studies on experimental reflex epilepsy

Another of Martino's major areas of interest was physiology. Martino focused, above all, on experimental epilepsy.

Reflex Epilepsy was also known as "Amantea's epilepsy" in honor of its discoverer. The history of this type of epilepsy is complex. In fact, before Amantea's discovery, it was already known that through electro-faradic stimulation of certain points of a dog's cerebral cortex, which corresponded to the motor or sensory-motor centers from which voluntary movements of the skeletal muscles originate, it was possible to cause a convulsive seizure analogous to those observed in humans, but only through the use of an intense and prolonged electric shock.

At the Laboratory of Physiology of the University of Rome, Amantea discovered that the experimental epileptiform activity could be generated in dogs even without the electrical stimulus of the cerebral cortex. In fact, it could be caused by a reflex arc, that is, by the artificial stimulation of certain areas of the skin known as reflexogenous areas.

To make this possible, it was necessary to increase the excitability of the corresponding brain center of the skin area designated to receive artificial stimulation: thus a disk of filter paper soaked in a solution of strychnine was applied.

Amantea had also noted that painful or tactile stimulation of the corresponding cutaneous reflexogenous zone increased the frequency, so the timing of the shock coincided with that of the tactile stimuli; thus if the frequency increased, the motor responses increased as well.

These responses, in some cases, turned into tonic-clonic contractions and persisted even after the tactile or painful stimuli had terminated. Furthermore, these contractions moved towards neighboring muscle groups so as to involve, in a matter of seconds, the entire muscular system causing a generalized tonic-clonic epileptic seizure with characteristics similar to those observed in humans known as "Jacksonian seizures" (Ferrari, 2002a).

In addition to these discoveries, Silvestro Baglioni and his colleagues had observed that the cortical motor centers and the sensory dorsal horn spinal cord centers both functioned as reflex centers.

In fact, after the application of strychnine on the cortical center a muscular clonus arose, which was preceded by hyperesthesia of the skin area functionally connected to the reflex center.

The clonus was facilitated by the artificial stimulation of this hyperesthetic cutaneous area, whereas it was hampered by anesthesia of the skin area caused by the application or infiltration of stovaine.

Amantea ascertained that when the hyperesthetic skin area was artificially stimulated, the onset of the epileptiform activity in the dog could be observed. As a consequence, the experimental form of epilepsy was called reflex epilepsy or epilepsy deriving from afferent excitations.

Initially, he considered this form of epilepsy as a particular type of experimental epilepsy corresponding to similar forms of particular clinical reflex epilepsy observed in humans; later, he argued that the reflex mechanism must always be at the base of epileptiform activity, regardless of whether the latter be provoked or spontaneous, or whether it occurred in humans or in animals.

In 1921 Amantea also noticed that there were dogs predisposed to reflex epilepsy and dogs that were not, thus offering epileptologists of the early Twenties a method of studying predisposition to epilepsy. By virtue of these guidelines, Gaetano Martino and his students were able to demonstrate that these observations were reproducible with similar results in the cat, the fox and other specimens of Mediterranean fauna (Ferrari, 2002b).

It was also observed that dogs that were predisposed to epilepsy were "biting" and violent and possessed a higher level of cortical arousal. These dogs, as the physiologist Antonio Alibrandi, a pupil of Martino, demonstrated, corresponded to the category of dogs that the physiologist Ivan Pavlov had classified as strong but unbalanced and they proved to be particularly quarrelsome and violent.

Pavlov later simplified his classification and reduced dogs to only two categories: dogs in whom excitement prevailed over inhibition and dogs in whom inhibition dominated over excitation.

Following these important studies, it was found that reflex epilepsy affected, above all, genetically predisposed individuals. Furthermore, three basic factors of Amantea's epilepsy were found: its constitutional predisposition, its exaltation of central excitability and the presence of afferent excitation (Martino, 1960a).

When Gaetano Martino left Messina to teach physiology at the Universidad Nacional de Asunción in Paraguay, he extended his observations to the Amazonian animal species, obtaining similar results to those from the research conducted on dogs, thus demonstrating that the distinction between predisposed and non predisposed organisms to this type of reflex epilepsy is universally valid (Ferrari, 2002c).

Experimental studies on reflex epilepsy conducted in 1965 by Alibrandi and Alibrandi Impò emphasized how the state of disposition towards experimental reflex epilepsy can be identified with a given condition that enables a prolonged posthumous effect of excitations beyond a certain limit. Therefore, the deionization of calcium of the sensory-motor cortical centers could represent a condition that renders the afferent excitations epileptogenic by prolonging their posthumous effect.

In this way, it was discovered that all of the factors that can modify the concentration of ionized calcium in the cortical centers may have a positive or negative effect on the propensity to develop experimental reflex epilepsy.

Numerous studies tried to identify which pathways may lead to a state of spontaneous disposition towards experimental reflex epilepsy by increasing or decreasing the concentration of naturally present substances in the sensory-motor cortical centers.

Studies found that an increased concentration of nicotinamide or deoxycorticosterone negatively influenced the state of disposition, whereas an increase of phosphate concentration, thiamine or testosterone exerted a positive effect.

Despite these results, further research focused on another vitamin factor that showed a significant interaction with calcium, that is rutin.

Rutin, which is a glycoside contained in Forsythia flowers, has the same effects on the heart as calcium does. In addition, rutin's most well known beneficial effect, fortifying the resilience of capillaries, is reinforced by calcium salts.

These considerations regarding rutin, which is the most active derivative of flavones and flavonols with vitamin P action, have further fueled the interest in studies on experimental reflex epilepsy.

The latter were conducted on a dozen dogs predisposed to experimental reflex epilepsy that were examined after intravenous administration of a 120 mg per kg dose of rutin dissolved via esterification with sulfuric acid (Alibrandi, Alibrandi Impò, 1965a).

This treatment was performed for ten minutes before the second check-up and it was observed that it could preserve five animals from developing an epileptic attack.

The seven remaining dogs, that had manifested a high level of disposition towards reflex epilepsy in the first control, showed a distinct abatement of epileptic propensity; in fact, after the first administration of rutin, their epileptiform activity was spaced over time.

These studies demonstrated that the antiepileptic action of rutin was probably due to its interaction with calcium; in fact, it was hypothesized that the calcium ions interfere with the ionic transport through the cell membrane thus rendering the ionic balance more stable (Alibrandi, Alibrandi Impò, 1965b).

Nevertheless, rutin appeared able to completely dominate only the less severe cases of experimental reflex epilepsy, hence making it ineligible as a strong antiepileptic drug.

In Messina's medical school, Alibrandi, Alibrandi Impò and Pellegrino conducted further research based on the studies of Professor Vito Longo, who discovered that animals predisposed to experimental reflex epilepsy had a relative adrenal insufficiency.

The predisposed animals, were not characterized by the tendency to present compulsive phenomena, which could remain dormant throughout the animals' lives. Rather, their condition was characterized by poor adaptation to the environment that could be avoided through the response of conditioned signals.

However, taking into account the fact that the animals had adrenal cortex insufficiency, the researchers redirected their attention towards the action of progesterone.

Progesterone, in fact, has an important influence on the production of adrenal cortical hormones: it can undergo a 21-hydroxylation, a 17-hydroxylation and also an 11 β -terminal hydroxylation, leading to the formation of corticosterone or cortisol, from which cortisone is formed.

Furthermore, by preceding the 11 β -terminal hydroxylation with an oxidation of the C-19 methyl group, aldosterone can be obtained.

In Alibrandi et al.'s (1965) study a paradoxical reaction was provoked in trained dogs, leading a strong signal to no longer produce the conditioned reaction, while a weak signal continued to provoke it.

The same cohort of dogs was treated with subcutaneous injections of progesterone of 1/10 mgr per kg of weight, dissolved in 1 ‰ sesame oil. Fifteen hours post-progesterone administration the paradoxical reaction didn't manifest itself or occurred in a delayed manner and the animal reacted in proportion to the intensity of the conditioned signal for a longer time than usual.

These results proved that progesterone plays a central role, however it was not understood if its action is direct or indirect, that is, if its action is a result of the products of the transformations that this substance underwent in the organism.

It must be remembered that the effect of progesterone was studied in specific regards to the paradoxical conditioned reaction (Alibrandi, Alibrandi Impò, Pellegrino, 1965). According to Pavlovian terminology, the term “paradoxical conditioned reaction” referenced the inversion of the relation between the energy of the conditioned stimulus and the effect it caused.

In fact, in neurologically normal subjects and in normal conditions, the intensity of the conditioned response was proportional to the intensity of the signal. However, in abnormal subjects or in certain conditions, such as in conditions of fatigue, strong signals could create minor reactions, such as those provoked by weak signals, or they could bear no reaction at all.

Thanks to Amantea’s and Martino’s research, experimental reflex epilepsy was not only discovered, but it was also demonstrated.

Martino’s contribution to the study of experimental reflex epilepsy in dogs is especially noteworthy in that he identified the nature of the causes that led to the generalization of strychnine induced clonus, while in most cases the convulsive activity remained tenaciously localized even after stimulation.

Thus Martino, through experiments conducted in Messina in 1932 and later at the University of Asuncion and Buenos Aires, was able to show that the predisposing factors that allowed the generalization of strychnine induced clonus were not already within the central nervous system, but reached it through the circulatory system, hence traveling through the blood.

He came to this discovery through a series of experiments that consisted in the injection of defibrinated blood, taken from predisposed dogs, into the jugular of non-predisposed animals, thereby causing the generalization of these critical events in the latter.

Martino managed to achieve similar results through crossed blood circulation between pairs of predisposed and non-predisposed dogs; the predisposed ones remained the same, whereas the non-predisposed dogs manifested a generalization of convulsions after receiving the formers’ blood (Ferrari, 2002d).

Amantea’s and Martino’s research served as the foundation for numerous other studies that followed. Nevertheless, many phenomena are still waiting to be discovered and investigated, as the uncertainties concerning epilepsy and its manifestations are still plentiful.

Regardless, Gaetano Martino and Messina’s School of Physiology are credited with having proposed and laid the foundations of the phenomenon of predisposition to epilepsy, which is a fundamental concept essential to finding the right therapy and preventive methods against epilepsy.

Studies on conditioned reflexes

In relation to his research on epilepsy, Gaetano Martino conducted research on conditioned reflexes, both in light of the high affinity between the two physiological phenomena and because of the use of similar experimental techniques.

Reflexes have always been of relevant importance in psychology, and they can be defined as:

« those individual reactions to external stimuli that form and manifest themselves during the animal's life, as a result of the frequently repeated association with reflexes or congenital reactions (that are constant and common to all the individuals of the same species) » (Martino, 1936a, 67).

For this reason they can be found in many expressions of the psychic activity of animals, such as in their personality, instinct and intelligence.

From 1935 to 1940 Martino conducted his research on conditioned reflexes in dogs. He was very interested in this topic because he considered reflexes as a means of making psychology less subjective and more objective. Martino was searching for a crossroad between psychology and physiology, so as to enable him to conduct a single and coherent discourse regarding the mechanisms underlying learning and memory (Marchetti, 2002a).

Studies performed on these individual or acquired reactions were based on the research of the Russian neurologist Vladimir Bekhterev regarding motor reactions which he called "associated reflexes", and on studies of Russian physiologist Ivan Pavlov regarding secretory responses, which, in 1903, he named "conditioned reflexes" or even mistakenly referred to as "psychic reflexes".

According to Pavlov, conditioned reflexes necessitated a hierarchically higher nervous activity with respect to ordinary unconditioned reflexes; in fact, the former required a memory trace of the sensation, usually associated with the motor or secreting process.

The conditioned reflex is highly specific for the corresponding conditioned sensory agent.

Pavlov's research was especially important because it served as a means to study signals and the relationship that is established between individual reactions and the outside world, and further favored the exploration of the experimental animal's personality.

Psychic reflexes, according to Pavlov, originated from physiological reflexes, that is, on the basis of species reflexes, and altered the latter in relation to sensory excitation.

Pavlov asserted that only the centrifugal segment of the physiological reflex arc remained constant, whereas the centripetal paths were modified and substituted with new paths that were different and distant from the original ones.

It should be remembered, however, that Pavlov's approach to studying the physiology of the nervous system and its plasticity was particularly rigid because of the scientific-historical context in which his research took place.

Martino, however, did not fully agree with Pavlov's ideas regarding the modifications of the reflex arc subsequent to the formation of a conditioned reflex. Together with his collaborator, Alibrandi, he devoted himself to the study of conditioned reflexes obtained by conditioning the dog in relation to a congenital reflex such as blinking, in an attempt to refute Pavlov's thesis about the replacement of the ordinary centripetal path in conditioned reflexes (Marchetti, 2002b).

The blink reflex is the rapid contraction of the musculus orbicularis oculi that can be elicited through an artificial stimulus of a specific cutaneous area called the reflexogenous zone.

Through this experiment, conducted at the Institute of Physiology of Messina, the two physiologists were able to elicit the onset of a conditioned reflex in response to a visual stimulus in a young dog, leading him to blink his left eye at the sight of a red lamp.

This conditioned reflex was established in the dog after a hundred and fifty trials of association between the conditioned agent and the congenital reaction.

It was observed that electro-faradic stimulation of one of the sensorimotor centers of the sigmoid gyrus provoked the contraction of the orbicularis oculi muscle, for the dog's conditioned blink reflex was located in that domain.

Even under ordinary conditions and generally in all dogs, stimulation occurring through a strong stimulus invariably provoked this motor response, also affecting the skin of the ipsilateral half of the face.

This was the innate or unconditional blink reflex, while the associative one was created by the two researchers by associating the unconditioned stimulus with a visual stimulus of sufficient intensity.

Once the conditioned reflex had been established, simply turning on the red lamp was sufficient to induce the motor reaction of the eye.

By studying the conditioned reflex of blinking in dogs, it was discovered that they depend on the sensorimotor cortical center to control the orbicularis oculi muscle (Martino, 1936b).

Thanks to these studies, Martino and Alibrando discovered that the acoustic or photic stimuli that elicited the conditioned blink reflex in the trained dogs lost their previously acquired capacity of exciting the reaction of blinking subsequent to stoivatisation of the reflexogenous cutaneous area of the congenital arc.

The associative reaction required the presence of afferent excitations that departed from the reflexogenous area of the innate reflex, also called the absolute reflex; thus the conditioned reflex arc also included the centripetal area of the unconditional reflex arc.

This research thus explained the acquired capacity of the excitatory acoustic or photic factor to provoke the blink reaction, accentuating the excitability of the center through processes of facilitation.

Therefore, even the smallest inactive excitations that continuously occur in the cutaneous reflexogenous area were able to promote the activity of the center; in fact the excitability of the sensorimotor center of the orbicularis oculis muscle increased considerably under the action of the conditioned stimulus.

Russian researchers, with regards to this experiment conducted by Martino, asserted that the ordinary afferent pathway would have been replaced by that of the optic nerve, ensuring the passage of the arc through the occipital cortex; vice versa Martino was able to ascertain that, in fact, the conditioned reflex took place through the participation of the ordinary afferent pathway.

According to Pavlov's theory, within the conditioned reflex, the afferent excitation of the peripheral sensory organ is conducted towards the sensory receptor; hence, the effector center is activated and then returned to the periphery through the effector nerve.

In this way, the reflex arc consisted of three parts: the first originated in the peripheral sensory organ and terminated in the receptive cell located in the brain, the second part enabled the receiving organ to communicate with the reflex or active center, the third part started in the reflection center and ended with the peripheral effector organ.

This theory was harshly criticized, especially in regards to the forced passage of the arc through the cerebral cortex. However, Pavlov did not directly address the theory of substitution by which one of the innate afferent pathways is replaced with the newly acquired one; thus appearing to support it.

The criticism originated from Gaetano Martino, as he managed to prove that the conditioned reflex did not imply the replacement of the ordinary unconditional or congenital afferent pathway, as Pavlov and the Russian

physiologists asserted. In fact, together with his collaborators, he demonstrated that the conditioned reflex occurred through the ordinary centripetal and centrifugal pathways of the unconditioned reflex (Martino, 1938a); thus the persistence of the ordinary afferent pathway was an indispensable prerequisite for the underlying mechanism of the conditioned reflex (Martino 1936c).

Therefore, the ordinary centripetal pathway was not replaced with a new one, new reflexes were not formed; hence, the distinction between congenital and acquired reflexes and between species-specific and individual reflexes was unjustified. The associative conditions always provoke cognitive reflexes, which are common to all species (Martino, 1938b)

This was demonstrated by anesthetizing the cutaneous reflexogenous area, enabling the researchers to observe that the conditional agent was incapable of causing the motor reaction. Thus minimal excitations, which always travel through the centripetal pathways of the congenital reflex arc, including those without an unconditional artificial stimulus, are indeed necessary for the mechanism of the conditioned reflex.

This was proof that the ordinary afferent pathway was an integral element of the functional structure of the conditioned reflex, proof that was also substantiated by the fact that the suppression of afferent excitation was enough to prevent the onset of the associative reaction (Martino, 1936d).

The repeated association between the absolute act with something that affects and stimulates the sensory organ generates the ability to activate the reflex center, thus causing the onset of the ordinary motor or secretory reaction. Consequently, it is impossible to create new reflexes that differ from mankind's congenital ones. (Martino, 1938c).

The controversy between Pavlov's and Martino's theories enabled the discovery of an important fact: every physiological reflex is the result of the constant manifestation of the most basic and fundamental neuronal activity.

Each reflex is the expression of an innate characteristic that is traceable in each individual of the species. For example, the secretion of the dog's salivary glands commences due to a food stimulus and the same reaction is observed and recorded every time.

This important congenital reflex, constant and, above all, common to all species, is called unconditional or, alternatively, physiological or absolute (Martino, 1960b).

If the reflexed secretion of the dog's salivary glands is repeatedly stimulated in a methodical way by means of a suitable stimulus, such as food or an acidic solution, it will be observed that after some time, the chemical stimulus

will no longer need to be in physical contact with the mucosa of the dog's mouth in order to induce the salivary reflex. In fact, mere indicators of the food or of the experience, such as the smell of that substance, or the view of its container or of the associated experimenter, or the dog's entry into the employed experimental laboratory, can be sufficient.

All these external factors such as visual images and olfactory cues have no relationship with the secretory activity of the salivary glands; in fact, they are nothing more than non-specific stimuli. The repeated association of these factors with the innate excitatory condition transformed them into adequate stimuli for the secretory process.

In this way, external agents that affect the sense organs can acquire the ability to associate the specific stimulus of the physiological reaction through repeated association with a congenital reflex.

New reflexes can be formed in a manner that does not depend on hereditary transmission, but rather are created from the expression of particular environmental conditions that are ordinarily associated with the congenital reflex in the individual's life. These reflexes are called conditioned, associative, acquired or psychic reflexes.

The conditioned reflex that is artificially provoked in animals is strictly specific and corresponds to the conditioned sensory agent; in fact, even slightly varying the intensity of the stimulus is sufficient to eliminate the reflex.

Upon analyzing their studies, Martino and Alibrandi noticed that there was an increased efficiency of the associated reflex, that is a greater energy, when acoustic stimuli were employed compared to stimuli produced by monochromatic lights (Martin, 1938d).

In the case of the dog that had been trained to blink in response to luminous stimuli, Martino and Alibrandi observed that when a less energetic stimulus preceded a more energetic one, the action of the more energetic stimulus resulted reinforced, whereas the latter exerted no effect on the reflex elicited by the weaker sensory agent.

One can see that this concept regarding the underlying mechanism of associative reactions adheres to the general rule of the reflex centers: *«the active state of the reflex center is always and solely induced by centripetal excitations that are congenitally destined to fulfill this purpose»* (Martino, 1960c, 812).

Through the succession of several different stimuli, "compound" or "higher order" or "chain" reflexes were processed and this was made possible by the association of the chain of sensory agents to the congenital reflex.

However, the processing of these chain reflexes hardly occurs in dogs, but it is very simple in man.

With regards to these chain reflexes, Russian researchers had taken into account the structure and use of words, conceptualizing them as a chain composed of a sequence of phonemes, and they discovered that chain processing of these phonemes was impossible for dogs because of a constitutional incompatibility of the dog's nervous system, but it was noted that the differentiation of the phoneme chains was possible.

Alibrandi, in fact, was able to obtain simultaneous processing of two distinct blinking reflexes using two different words: for example, the right eye blinked in response to the word "one", and the left eye to the word "two" (Martino, 1960d).

The negative results obtained by the Russian scientists were due to the fact that they had not taken into account the individuality of the animals.

Alibrandi, instead, had noticed that dogs characterized by an insufficient inhibition process for differentiation were not able to process the conditioned reflexes in response to the spoken word. However, by artificially increasing the dog's ability to discriminate through the use of barbiturates, the processing of these reflexes became possible.

These studies underline the importance of conditioned reflexes, especially as they constitute a valuable means for the objective study of human and animal feelings.

Conclusions

The research performed by Martino saliently contributed to the advancement of science and in the wake of his work, numerous other studies were carried out.

Martino was an excellent teacher, a deft leader and he ought to be credited with having passionately discovered and investigated numerous physiological and psychological phenomena.

For this reason, the studies conducted by this eclectic physiologist can be classified within many fields of investigation, both physiological and psychological ones.

In particular, his research on reflexes played an important role in the development of psychology, which was trying to define and affirm itself in Italy in those years.

Furthermore, thanks to his studies on conditioned reflexes, psychology and psychiatry have found, and continue to find, important developments towards the understanding of man's personality.

In addition, although Martino described a critical flaw pertaining to Pavlovian theory, he nevertheless credited the salience of the Russian physiologist's contribution in the field of psychic phenomena: indeed, despite Pavlov's errors, his theory granted psychology a quality method with which to objectively investigate the events of psychic life.

In regards to psychic functions, Martino asserted:

« These are also, despite the purely arbitrary separation between physiology and psychology, the events of normal life, strictly physiological phenomena. Thus, physiological inquiry is absolutely essential to their study. » (Martino, 1938, 11).

Martino was able to find an objective method for psychological investigation and a point of unity between physiology and psychology, between body and mind.

This Messinese physiologist, by virtue of his indisputable dedication and passion for research, managed to open a prolific dialogue between two apparently distinct and distant disciplines, actively moving towards an interdisciplinary approach, thus anticipating a basic principle of present-day science.

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