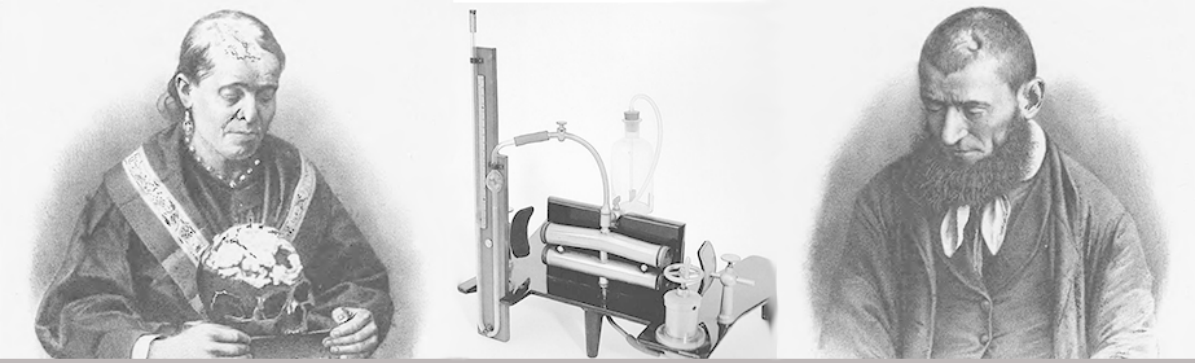

Blood circulation and nerve impulses The research on the blood circulation in the brain Brain temperature

Blood circulation and nerve impulses

In 1875, after three years of research in Florence, Leipzig and Paris, Angelo Mosso came back to Turin, where he became Professor of Physiology in 1879 with the departure of Jacob Moleschott for Rome.

The new plethysmograph allowed him to study the movements of blood vessels and Mosso had the idea of using it along with the *hydrosphygmometer*, which allowed him to distinguish the movements of the blood vessels that depended on the influence of the nervous system from those

that stemmed from local actions. In the pulse, movements dependent on the cardiac impulse had to be separated from those which depended on the vascular contractions.
"My opinion of these variations in a quite long series of experiences is that they depend in part on a difference in the energy of the cardiac contractions and in part also on a change in the elasticity of the vessel walls" (*Continuazione della Memoria 'Sulle variazioni locali del polso nell'antibraccio dell'uomo'*, 2 December 1877, p. 146).
Sulle variazioni locali del polso nell'antibraccio dell'uomo

Memoria 2 dicembre 1877 continuazione 2 dicembre

Following the approach of Jules Marey and Carl Ludwig's studies on blood circulation, Mosso was interested in the movements of the arterial vessels in experimental subjects at different temperatures, in wakefulness and sleep, but also under the influence of the so called "psychic impression". For example that produced by a sudden noise. In 1894 Mosso sent, through Friedrich Kiesow, a sphygmomanometer model he had designed, to Wilhelm Wundt in Leipzig who used it to study changes in blood pressure during intellectual work and under psychic stimulation. Meanwhile, Mosso himself had begun to implement the findings on the circulation even to the brain, because in fact the blood movement was not limited to the pulse in the hand and forearm, but also extended to functioning of the brain involved in higher faculties. In the first part of the essay "*Sulle variazioni locali del polso nell'antibraccio dell'uomo*" (18 november 1877, p. 39) he referred to the essay *Introduzione a una serie di esperienze sui movimenti del cervello* published in the "Archivio per le Scienze Mediche" (1876), and he noted that in the human forearm and the brain there are periodic changes in vessel volume, similar to those already observed by Moritz Schiff in the rabbit ear.

The research on the blood circulation in the brain 

In the Seventies Mosso began his collaboration with Carlo Giacomini, with whom he conducted clinical trials that led to the first recording of human brain pulsations. In the above mentioned essay *Introduzione a una serie di esperienze sui movimenti del cervello*, written together with Giacomini, initially Mosso provided a full historical review in order to highlight the mistakes of the past. He pointed out that generally physiologists shared the idea that any accumulation of a certain amount of blood in the brain was accompanied by a corresponding shift of cerebrospinal fluid in the spine, and vice versa. But still in the mid-nineteenth century the graphic techniques were very rudimental. On the first page of *Esperienze sui movimenti del cervello nell'uomo*, published together with Giacomini (1877), Mosso was amazed to note the lack of importance that research into diseases and injuries of the skull had in the past for the advancement of physiology. The ease with which experiments on animals were performed had made any investigation of the human brain useless. The first pioneering experiments conducted by mid-century with more exact methods of investigation are the works of Victor von Bruns (1882-1903), a German surgeon who used a lever to amplify the movements of the brain and he observed that the volume of the brain increased under a stressful stimulus. Among other studies that he mentioned are those by Ernst Viktor von Leyden (1832-1910) and by the French doctor Jean-Baptiste Langlet (1841-1927) on the movements of the brain of children during sleep.

Mosso 1876_206

Mosso 1876_245

Following this line of research Mosso now could present his own case study, that of Caterina X, a farmer of 37 years, admitted to the hospital of St. Lazarus with syphilis. This venereal disease had eroded the upper part of her skull, from the nasal bones to the occiput. A necrotic part of her skull was removed, a portion of the *dura mater* as large as a shield was exposed, a recording device was applied and with it "the most beautiful tracks" of the cerebral movements were obtained in

physiology. With a system of tympani or *tambours* (in particular the *tambour explorateur*) taken from Marey, the last of which was attached to a button, with every pressure exerted by the brain on the button, the air was pushed in the tympani. From tracings it was noted that, like the forearm, the brain showed periodic fluctuations dependent on breathing, but also in response to other origins. In particular, the *undulations* were more sweeping curves, present during moments of attention, in brain activity, sleep and other situations. Therefore, Mosso and Giacomini came to the conclusion that "all movements of the body, or of the soul, reflect on the volume of the brain, at the same time by changing the profile of the pulse" (ibid, p. 278).

Sulla_circolazione_del_sangue_nel_cervello_dell_uomo__memoria___7_dic_1879_Atti_della_R_Accademia_dei_Lincei

In 1878 the physicist Pietro Blaserna, in the presentation of the work made by Mosso to the Academy of Lincei, commented that it was a relevant research in psychology "for the knowledge of the relationships linking the material brain functions with the mysterious processes of thought". On that occasion Blaserna gave notice of a new, even more complete, piece of research conducted by Mosso: the observations on Michele Bertino.

Sui_movimenti_del_cervello__16_giu_1878_Atti_della_R._Accademia_dei_Lincei

These cases (Caterina, Bertino and Giovanni Thron, a retarded epileptic, whom Mosso observed with G. Albertotti) were presented by Mosso in a “Memoria”, *Sulla circolazione del sangue nel cervello dell’uomo*, lectured at the Academy of the Lincei on December 7, 1879, published in Rome in 1880, and re-published on the “Archivio per le Scienze Mediche” in 1882.

Sulla_circolazione_del_sangue_nel_cervello_dell_uomo

Mosso_1882_44

Mosso examined the effects of the emotional states in the transition from a condition of rest to an intense brain activity in more detail. He noted the sharp contraction of the vessels at the body surface and the increase of blood pressure and volume in the brain, as a result of a more abundant bloodstream, especially in the cases of "moral emotions”. This result did not occur in the forearm, where there was a decrease in volume. In fact, moral emotions affect the cerebral blood circulation far more conspicuously than does “intellectual work”. Mosso realised that the brain is an organ independent of the direct voluntary control, and the chapter IV, specifically devoted to “the blood circulation during mental activity and emotions”, opens with the following observation:

> “The study of the changes that the blood circulation undergoes under the influence of the cerebral activity is a problem fraught with difficulties, if one wants to distinguish the modifications of the blood stream which are proper to the brain from those belonging to the whole organism”

Mosso was convinced that these variations depended more on a change of the “energy of the intellectual activity” than on a real passage from the state of absolute rest to one of complete activity. When Bertino interpreted some Mosso’s requests as a reproach, the cerebral pulse in the tracing turned out higher than before. Mosso concluded that Bertino was seriously concerned by his words. In particular, Fig. 22 is a good example of the modifications of the cerebral blood circulation during an arithmetic task: the cerebral pulse and volume increased during the entire duration of the intellectual activity or, if the question was easier, at the start of the mental operation.

Other fundamental chapters regard cerebral activity during sleep. Mosso made the assumption that during sleep there is a period of such profound rest of the cerebral hemispheres that all “work of ideas” ceases. He concluded (§ 6.3) that during sleep “a series of unconscious impressions are registered”, which can alter the functions of the organism without trace in the memory. Nevertheless these alterations are important, since they prepare the material conditions for the awakening of the consciousness in case of danger. In this regard Mosso quoted the conception of Herbert Spencer in his *Principles of Psychology* (1855) about the balancing of greater or lesser abilities in the organism (according to the alternation of day and night) necessary to adapt to change. Mosso emphasized the role of the “reestablished material conditions for consciousness”, because in “its struggle for existence” the organism prevails, which carries out the most perfect “unconscious surveillance of external stimuli”. As Maria Sinatra observes, it is about an *unconscious* “defined in mechanistic terms of associative involuntary and latent responses" (*La psicofisiologia a Torino*, p. 139). Mosso called in the doctrine of the unconscious activity of the conceptual centres exposed in Henry Maudsley’s *Physiology of Mind* (1876), according to which, when an idea “fades” from the consciousness, it does not necessarily disappear completely, while it can remain latent below the threshold of conscious awareness. Therefore, during the state of deep sleep, in the period of rest of the psychic centres, all the conceptual activity is suspended.

Mosso recognized that changes in the brain functions when the blood flow increases or decreases are the most interesting studies which psychologists may tackle *experimentally*, since they denote in an evident way the "very narrow" link between psychological and material functions of the organism. It is sufficient to diminish the amount of blood in the brain and consciousness immediately ceases. In this process of *naturalization* of consciousness the graphs constituted the physiological side of the “psychic", and in the brain the renewal of tissues and molecules is particularly active, while the higher elevation of psychic phenomena is dependent on the greater complication of material facts.

Brain temperature 

In 1894 Mosso published *La temperatura del cervello* dedicated to Hermann von Helmholtz. This work had been preceded by the essay *Les phénomènes psychiques et la temperature du cerveau*, which was the French translation of Croonian Lecture to the Royal Society in March 1892. Even in this circumstance Mosso noted that psychic phenomena were the cornerstone around which his experiments on the temperature of the brain were performed. Following the observations made on the little girl Delfina Parodi, Mosso with great intellectual honesty acknowledged that

> “the psychic facts alone are not enough to produce a significant heating of the brain. The strong elevation of brain temperature observed during sleep depends on the nature of unknown phenomena accompanying psychic phenomena, but inconsistently and irregularly. To these changes I have given the name of organic conflagrations” (*La Temperatura* op. cit., pp. 181-2).

La_temperatura_del cervello_A.Mosso

Conclusion

Probably inspired by Paolo Mantegazza’s *La fisiologia del dolore* (1880), in 1884 Mosso published his popular text on fear, with which he followed the physico-mechanistic tradition, inherited from Descartes, Darwin and Spencer. As to the causes for which one flushes, Mosso observed that "also the brain becomes red after an emotion": the redness in the rabbit ears and on human face is an effect of the “our machine structure”, a function of the blood vessels.

We would like to conclude with a paragraph of *La paura*, which represents his intellectual legacy with regard to the question of the mind/body relationship. It is a conception equally apart from spiritualism and materialism, but that expresses an undiminished faith in the science and in

advancement in the knowledge of the "physico-chemical movements which agitate the hidden parts where consciousness is located".

La Paura

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