

The Skin Constrictor (Psychogalvanic) Reflex.¹

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THE term 'psychogalvanic reflex' has been given to the fall in the electrical resistance of the skin which occurs during mental effort or emotion. It is probable that the fall in resistance is not the sole change which occurs, but from the work of Thouless it is evident that it is by far the greatest change concerned. Various explanations have been sought for by individuals whose interests lay in special directions and who were not fully acquainted with the literature of the subject or with the physiology of the factors concerned.

It will be shown below that the fall in resistance can readily be explained as being the result of constriction of the blood vessels of the skin. In the past, this conception has been ignored because of the fact first noted by Veraguth, that the reflex was not abolished by the cutting off of the blood to the part concerned. Since, however, it has become realised, largely as the result of the investigations of Krogh, that the peripheral vessels are independent of the blood pressure, such negative evidence carries no weight.

THE INFLUENCE OF THE CIRCULATION ON THE RESISTANCE OF THE SKIN.

In the past too little attention has been paid to this aspect of the problem. In 1924, however, Aveling, McDowall and Wells carried out a series of experiments on chloralosed or decerebrate animals in which it was found that all procedures calculated to bring about vaso-constriction in the skin, *e.g.* hæmorrhage, adrenaline and cold, caused a fall in the electrical resistance; while conditions producing vaso-dilatation, *e.g.* obstruction of the venous return, caused a rise. They found that the fall could be brought about by sensory stimulation in a decerebrate animal, thus showing the elementary nature of the reflex, and suggested that the term 'skin constrictor' reflex should be substituted. It should be stated that conclusive evidence was obtained that the change in electrical resistance was not brought about by activity of the sweat glands. This sweat hypothesis was shown to be based on ignorance of the pharmacological action of pilocarpine and atropine. It was actually shown that pilocarpine, in the sweating stage when the blood-vessels are dilated, caused a rise in resistance, although it may be preceded by a fall in the pallor stage. In this point the results of Waller were confirmed. In final condemnation of the sweat theory, it may be stated that Golla records an example of neurotic hyperidrosis in which the sweat literally dripped from the patient who gave a normal reflex. It is inconceivable that such activity would not interfere with the reflex were it due to increased glandular activity.

The work has now been further extended by Wells, who has shown in a very simple series of experiments, the details of which will be given in a forthcoming paper, that any alteration of the circulation through the skin of the hand causes a considerable change in electrical resistance, greatly in excess of that occurring in the reflex. For example, if the carbon dioxide which normally keeps up the tone of the vasomotor centre be reduced by over-ventilation, a procedure producing an obvious pallor of the skin, the fall in resistance may amount to 20-30 per cent. of the original resistance. On the other hand, if the peripheral vessels be dilated by preventing the normal

venous return by compression of the arm with a sphygmomanometer cuff at a pressure of 50 to 60 mm., there is a marked rise in resistance.

It is, however, important to note that all such experiments can only be carried out if conditions, as indicated below, are such that vaso-constriction can show itself; while it is not until the subject is thoroughly accustomed to the procedure of the experiment that the effect of psychical states can be got rid of.

THE INFLUENCE OF THE CIRCULATION ON THE REFLEX.

It has long been known that in cold weather it may be very difficult to obtain the skin constrictor reflex; indeed, it is a routine procedure amongst psychologists to wash the hands in warm water in such circumstances. It is evident that if the cold causes the skin vessels to be constricted, no further constriction may be expected. Mere compression of the skin vessels by the electrodes may prevent the reflex from showing itself. There is little doubt that this accounts for the fact that it is most readily obtained from the palms of the hands and the soles of the feet, since the superficial blood-vessels in these regions are protected by a greatly thickened stratum corneum. This may readily be observed by pressing the finger on the palm and back of the hand and comparing the pressure necessary to cause an evanescent pallor. There seems little doubt that the failure to obtain a rise in resistance in blushing is due to the fact that the vessels in the face are exposed, since Wells has shown that hyperæmia of the hand, produced by plunging the hand alternately into hot and cold water, gives a marked result.

In the usual method of obtaining the reflex there is added to the pressure of the electrodes the cold due to evaporation of the saline by which they are kept moist, while the skin becomes sodden. All these factors may interfere with the appearance of the reflex.

Similarly, the reflex is abolished by drugs which cause marked dilatation and paralysis of the skin vessels, such as large doses of alcohol and atropine.

It is important also to remark that many observers who have been unable to explain the fact have noted that there is great difficulty in obtaining the reflex in patients suffering from arterial disease such as arteriosclerosis.

EVIDENCE OF VASO-CONSTRICTION DURING THE REFLEX.

It is stated by Krogh that if the ear of an un-anæsthetised rabbit is observed, the occurrence of the slightest unusual sound causes the blood-vessels in that region to become constricted; while Carrier, working in the same laboratory, has recorded closure of the skin capillaries of man during a thunderstorm which caused much apprehension in the subject. Hemingway in this laboratory, using Lombard's method, has found that there is commonly a closure of the capillaries of the skin during conditions which produce the reflex. The constriction is, however, limited to certain capillaries, while others remain permanently open. To be certain of these changes it is necessary to observe a given area of skin for several days in order to be thoroughly familiar with the normal state of the region; and due precautions must be taken to prevent the capillaries being affected from other causes during the observations.

¹ Summary of a paper by the authors before Section I (Physiology) of the British Association, delivered at Oxford on August 5. (From the Department of Physiology, King's College, University of London.)

It would be expected from the foregoing that if the reflex is caused by vaso-constriction, there ought to be a diminution in the volume of the limb as shown by the plethysmograph. This has been thoroughly investigated by Golla, and in a Croonian lecture he states that he not only found that there was a constriction of the limb, but also that the time relations and the degree of constriction corresponded to the change in electrical resistance. We have fully confirmed these results, which may readily be demonstrated by the 'rubber glove' method.

On searching the literature the extremely interesting fact has come to light that this was the first experiment of its kind ever done by Mosso, the inventor of the plethysmograph. Mosso records that so important did he consider the experiment that he visited Ludwig in Leipzig to demonstrate it. So impressed was the 'father of physiology' by the reduction in the volume of the limb of the subject, Prof. Paglianni, that he wrote in German on the tracing "Enter the lion."

Mosso goes on to relate how the volume of the limb changed in a subject passing from 'seen' to 'unseen' Greek translation, and remarks that in such emotional constriction we have the explanation of the common saying "Cold hands and a warm heart."

Since the blood flow through the skin influences an individual's temperature sensations, a number of common sayings such as "the blood running cold," "the pallor of fright," "eat till you grow cold," may be considered to have been placed on a definite physiological basis.

Taken together with the experiments on animals, it appears clear that the reflex is a very elementary one which may be brought about without co-operation of the higher centres, as the result of sensory stimulation. It should therefore be known as the *skin constrictor reflex* and may be considered as part of the mechanism by which the animal normally adapts itself to the anticipation of muscular exercise and defence. In man it occurs not only on sensory stimulation, e.g. of a pin-prick, but also in anticipation of the stimulus. Here we may look upon a threatening movement as a conditioned stimulus which has developed as an effect of experience. The fact that many of the emotional stimuli affecting civilised man may bring about a reflex so closely associated with sensory stimulation physiologically and apparently teleologically, suggests that in responding to such stimuli the individual is, in a sense, defending or preparing to defend himself. The problem appears to offer an excellent line of psychological investigation.

Fuel Research.

AT the postponed annual general meeting of the Institution of Gas Engineers, commencing September 21, a number of papers were submitted, some of a professional kind, dealing with such subjects as the layout and extension of works, and the supply of high-pressure gas, while others dealt with the principles and problems of carbonisation.

Among the latter was the sixteenth Report of the Joint Research Committee of the University of Leeds and the Institution of Gas Engineers, which contained the first results forthcoming from a systematic study of the different factors which influence the results obtained in the carbonisation of coal. The first factor examined was the influence of the size of the coal particles, which was shown to exercise an appreciable influence not only on the strength and nature of the coke produced, but also on the gas yield, this latter fact being traced to a cracking of the tar, which was more pronounced with the charges made up from the smaller sizes of coal. The retort used for the process was of 'Cronite' metal supported by a complete fireclay sheath, which enabled a gas-tight apparatus to be secured working at a temperature of 1000° C. without deterioration. A carbon balance could be struck, and also a thermal balance, which confirmed the deduction previously made that the products of carbonisation contained within 2 per cent. or 3 per cent. as much potential heat of combustion as the original coal.

A paper dealing with somewhat similar subjects was submitted by Mr. T. F. E. Rhead, who described results obtained on the experimental plant of the Birmingham Corporation Gas Department. Mr. Rhead concluded by a plea for closer scientific supervision of the retorting process as essential if it is to be carried out efficiently and economically.

C. B. Marson and J. W. Cobb reported striking results which they had obtained in studying the influence of the ash constituents in the gasification of specially prepared cokes in steam and in carbon dioxide. Working on a coal containing only 1 per cent. of ash, it was found that additions of 5 per cent. of different oxides made, in some cases, great difference in the results obtained. With the same rate of

steam supply, the percentages decomposed were 61 for 'pure' coke, and 82, 91, and 98 for the calcium oxide, iron oxide, and sodium carbonate cokes respectively, while the corresponding percentages of carbon dioxide in the water gas generated were 9.2, 5.4, 21.6, and 0.4 respectively. Again, the percentages of carbon monoxide found after passing carbon dioxide at the same rate through the different cokes were 6.6, 29.9, 45.6, and 89.0 for the 'pure' coke, iron oxide coke, calcium oxide coke, and sodium carbonate coke respectively, while the enhanced reactivity was also displayed by the figure for quantity in grams gasified per hour, which was more than twenty times as great for the sodium carbonate coke as for the 'pure' coke. The increased reactivity of these special cokes so tested was, in the main, due to the specific catalytic effect of the added compound, and not to the alteration in physical structure on carbonisation resulting from the addition, which was sometimes itself quite remarkable. The importance of the results in connexion with such subjects as the preparation of a free-burning carbonised smokeless fuel is obvious.

The fifteenth Report of the Joint Research Committee of the University of Leeds and the Institution of Gas Engineers was of a preliminary nature, and was concerned entirely with a careful and detailed examination of the conditions which have to be satisfied if trustworthy determinations are to be made, by the iodine pentoxide method, of any carbon monoxide produced in the use of typical gas appliances.

Another report submitted at the meeting was that of the Refractory Materials Committee, in the form of a series of papers. Among these may be mentioned papers by A. J. Dale, entitled "The Testing of Refractory Material for Resistance to Slag Corrosion and Erosion," and "The Control of Silica Brick-Making, based on Load-Test Indications," one by E. J. Vickers, entitled "The Influence of Oxidising and Reducing Atmospheres on Refractory Materials," and another by A. T. Green, continuing his work on "Temperature Diffusivities and Thermal Conductivities in relation to Silica and Fireclay Refractories."