A FURTHER NOTE ON THE POSSIBLE STRUCTURES MEDIATING MIND.

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The object of the present paper is to point out that two different working parts of muscle have hitherto been generally confounded together, whereas their analogues in the psychic mechanism have always been deemed separable. Scientific explanations of the phenomena of mind, however, seem ultimately to wait on knowledge of what happens in excitable tissues, such as muscle, so that the result of finding two working parts in the psychic mechanism, where it was believed there was only one analogue muscle, has been the introduction into physiological psychology of a number of what I have to suggest are superfluous terms. In addition, the present paper deals with the possible nature of the connection between cerebral excitation processes and the psychic response.

The present start is made by first taking the reader back to the time when, as a student of physiology, he applied an induced shock to a muscle and observed the resulting twitch. This experiment is as old as the application of electricity to the investigation of physiological phenomena, and the original interpretation of the result was that the " muscle " was excited by the electric current. This interpretation, however, was early subjected to attack in the form of the suggestions that muscle itself was not " excitable," and that the electric current really excited the nerves, or nerve-endings, in the muscle. But these ideas were abandoned when other experiments showed definitely that muscles possess their own proper excitability.

This point concerning the possession by muscle of its own excitability having thus been decided, it was then generally assumed that the contractile material of muscle could be directly acted upon by the electric current and thereby stimulated to contraction.

But a paper published a quarter of a century ago by Macdonald on the structure and function of striated muscle showed that the physical properties of muscle were such that its sarcoplasm

https://doi.org/10.1192/bjp.77.317.351 Published online by Cambridge University Press

acted as an electrical insulator of the actual contractile material (3). That is to say, an electric current sent into a muscle exerts no direct action on contractile material, but instead on sarcoplasm, so that the activity of contractile material is really excited through the sarcoplasm.

Two different excitations, thus, follow the application of an induced shock to muscle: the electric current first "excites" and sets up in the sarcoplasm an excitation process which, in its turn, excites the activity of the contractile material, or muscular responding organ.

A corollary to Macdonald's exposition is that it should be possible to abolish the excitability of a muscle to induced shocks without impairing its capacity to contract. That this is so I have repeatedly shown.

The doctrine of receptive substances, associated in particular with the name of Langley, implies the same mechanism, but in a less satisfactory and indefinite form. He recognized from his experiments that there must exist between the contractile material, or contractile molecule, and the muscular or gland-cell environment some intermediate body, or receptive substance, on which stimuli from that environment first acted. Then these stimuli, having first acted on the receptive substance, caused this in its turn to set up activity in the contractile molecule. He made, however, Ehrlich's side-chain hypothesis part and parcel of his own, and so was led further to make the receptive substance a mere side-chain of the contractile molecule instead of a definite independent structure, with its own qualities for investigation. In the heart, for instance, the excitation process travels by the bundle of Stanley Kent and its ramifications and during passage excites contraction.

I would next draw attention to the point that the intermediate body plays on, or activates, the responding organ through setting up differences of electrical potential at a "Nernst" semi-permeable membrane, *i.e.*, by "action at a distance" (1, 3). The response and the excitation process which evokes it can thus be as radically unlike one another as the electric currents in a telephone wire are unlike the spoken voice. Yet, by a suitable structural arrangement and "action at a distance," every variation in the excitation process type of energy can be faithfully reproduced in the entirely different form of "response" energy.

This point, that an induced shock does not directly excite the contractile material of muscle, though it finds general neglect, is yet one of the highest importance, because the conceptions of what

happens in muscle find general application. They find particular application when one deals with the relations between consciousness and nerve-cell change.

The conception here given, and implied in previous papers, is that consciousness is a form of activity of a definite structure, which I have termed the responding organ, the exact like of which is not to be found in or associated with any other organ of the body. Instead there is found the analogue. And, on this basis, we should no more expect to find consciousness in a muscle than we should expect to find a muscle secreting saliva; also we can no more suggest that the brain secretes "thought" than we can suggest that a muscle secretes contraction. What we can expect to find some day, however, is that structure and "action at a distance" can transform in the brain the energy of nerve-cell excitation processes into those forms which we term "consciousness" and "feeling."

If, however, our speculations are based on a belief that induced shocks directly excite the responding organ of muscle, we have the difficulty that the only change they can be observed to produce in nerve-cells or nerves is an excitation process. This, of course, is all these shocks do in muscle, but investigators believed they did more in that the contraction was the culmination of the excitation process. Hence also consciousness should have been deemed to be the culmination of a nerve-cell excitation process—a possibility that investigators have generally been unable to believe. A number of terms, in what may be called physiological psychology, indicate this disbelief and, as examples of these terms, there may be quoted "emergent," "epiphenomenon," and "psycho-physical parallelism."

These terms, however, should really be regarded as superfluous, and therefore be discarded, because, if we regard them as possessing any special value, we ought also to begin calling a muscular contraction the "epiphenomenon," or the "emergent," or the "contracto-physical parallel" of the muscular excitation process. Likewise digestion would be the "emergent" of a digestive gland and so on. But, while discarding these terms, we should appreciate that they were actually necessary so long as it was believed that in muscle excitation processes and contraction took place in one structure.

What has been happening, of course, is that a number of investigators have possessed as naïve a view of what they meant by the word "muscle" as that meant by many motorists when they

use the word " motor." And just as motorists should realize that a motor is not merely something that " moves " when a button is pressed or a handle turned, so also should it be realized that a muscle does not merely " contract," but possesses within it a complicated series of working parts such as " cylinders " of definite capacity, a " sparking " mechanism, a " feed " and so on.

If, next, we apply to mental phenomena the conceptions derived from muscle that there exists for these mental phenomena a " responding organ " of definite and limited capacity, made active through two independent sources of potential, then the mechanism I have given introduces something of " law and order " into regions where the " pure " psychological approach finds nothing but personal whim.

The differences I would exemplify by discussing some of the results attendant to a group of men blown up by a shell. The psychological method of approach to this problem, so it seems to me, reveals some of the men taking a miraculously quick decision to forget the event, whereas the others, not having so decided, manage to remember it. A mechanism of the type given above, however, would make the difference between " remembering " and " forgetting " dependent, not on individual desire, but on the relations between the strength of the impression, or L, received from the burst by the individual and the capacity of his responding organ, or T. When the values of L and T approximate, the " memory " becomes ultra-cognoscible, whereas when L is distinctly less than T there can be applied to the memory trace, or L, enough of the factor H to mediate consciousness of the event (2). Other things being equal, the man with the larger T would be more liable to develop an ultra-cognoscible memory than the man with the smaller T.

References.—(1) Burridge, *Journ. of Physiol.*, 1911, xlii, p. 359.—(2) *Idem*, *Journ. Ment. Sci.*, 1931, lxxvii, p. 345.—(3) Macdonald, *Quart. Journ. Exper. Physiol.*, 1909, ii, p. 65.