The Time taken in passing the Synapse in the Spinal Cord of the Frog.

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(Abstract.)*

The time taken by an impulse to cross a single synapse has been estimated by the measurement and comparison of cord-delays in different reflexes of the decerebrate frog. The cord-delay was determined by measuring, (1) the interval of time which elapsed between the moment of application of a single break induction shock to a nerve containing afferent (sensory) fibres and the moment of appearance in a particular spot of a particular muscle of a response, known to have no latency of its own (the electrical response), and shown to have been produced by the excitation of the afferent fibres; by then measuring and deducting from this time-interval, (2) that which elapsed before a response occurred in the same spot of muscle when the same or a similar induction shock was applied to the efferent (motor) fibres of the nerve supplying it. From the remainder the time was deducted which would be taken by an impulse travelling at the rate of 30 metres per second to traverse the measured length of nerve between the two points of excitation.

The recording of the intervals was automatic, the movements of the meniscus of the capillary electrometer, the two terminals of which were connected with the muscle, being photographed on plates moving at known rates. The recording muscle chosen was the gastrocnemius, and the nerves stimulated were the sciatics of the same and of the opposite side. The experiments were all made on autumn or winter frogs.

It was found that a single induction shock was only capable of producing a true reflex response in the gastrocnemius from a normal cord when applied to the sciatic of the same side. The same stimulus applied to the opposite sciatic only produced the response when the excitability of the cord had been raised by some drug. The drugs used for the purpose were strychnine and phenol.

When the same-side sciatic was stimulated, the reflex response in the muscle was quite distinct from the response produced directly by the excita-

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tion of the motor fibres. The difference of time between the two responses was hardly altered by the administration of strychnine so long as the dose was not strong enough to produce spasms or to affect the general circulation. It was, however, slightly shortened, the cord-delay varying in normal cords between 0·012 and 0·022 second, and in strychnine cords between 0·009 and 0·020 second. With stronger doses of strychnine the cord-delay was considerably lengthened, probably as the result of impairment of the circulation.

When the sciatic of the opposite side was stimulated and the excitability of the cord raised just sufficiently for a reflex effect at all to be produced by the stimulus, the cord-delay was always about double what it was in the same-side reflex. In the strychnine cord of preparations the circulation of which was still unimpaired, the extra-cord-delay in the case of the crossed reflex became very rapidly shorter as the action of the drug continued and might even be reduced to one-fifth of its original value in a preparation in which the total cord-delay in the same-side reflex was hardly altered during the experiment. It was, however, never reduced to less than 0·004 second. In preparations in which the reflex responses were spasms, or in which the circulation was impaired, it also was always long, although not usually quite so long as the total cord-delay in the same-side reflex. In such preparations in both kinds of reflexes the central stimulus often failed to produce its maximum effect on the muscle at the beginning of the response.

The effects of altering the temperature of the cord, and of altering the strength of the artificial stimulus applied to the nerve, and of fatigue, on cord-delay and on extra delay respectively in the two kinds of reflexes are dealt with in the full paper.

It is suggested that the method of measuring cord-delay employed gives the clue required for ascertaining the number of synapses involved in succession in any particular reflex, and that there is normally *one* synapse interposed in the conductive path of each individual fibre concerned in the same-side reflex investigated, *two* in that of each fibre concerned in the crossed reflex. It is pointed out that the numerical results obtained refer, as a rule, rather to the modal time than to the shortest time in which a synapse may be passed, and reasons are given for believing that the set of synapses alone involved in the same-limb reflex, the primary synapses, are wont to act much more synchronously than the set of secondary synapses involved, in addition, in the crossed reflex, when the cord is normal. The nature of the action of strychnine on the cord is also discussed.

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