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Antagonist Inhibition as the Earliest Sign of a Sensory-Motor Reaction

REACTION time is defined as the interval of time between a sensory (optic, acoustic, tactile, etc.) stimulus and the voluntary reaction of muscular contraction. The values of reaction time for a given sensory-motor reaction show the smallest variation when the subject is alertly expecting the sensory stimulus. Even so, there is considerable variation of reaction time between different subjects. Individual differences are of less interest, however, than the lowest value of reaction time obtainable in optimal circumstances if the minimum time of cortical integration for a sensory-motor reaction is to be studied. The time of cortical integration is obtained by subtracting the afferent and efferent conduction times from the reaction time[1].

So far, only the electrical or mechanical manifestations of muscular contraction in agonists have been studied as examples of voluntary reaction[2]. We have undertaken a study of the simultaneous changes in muscles antagonistic to the voluntary movement of the reaction.

In our experiments, the sensory stimulus was evoked by an electric shock to the N. medianus in the fossa cubiti, of a strength which gave only a tactile perception. The electrical activity of the

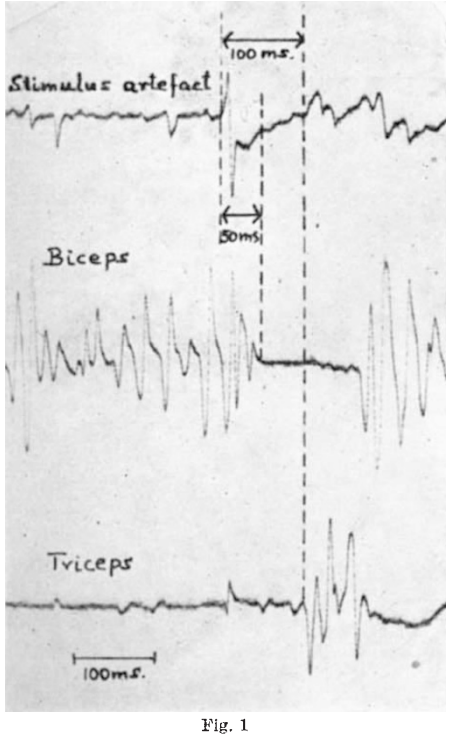

Fig. 1

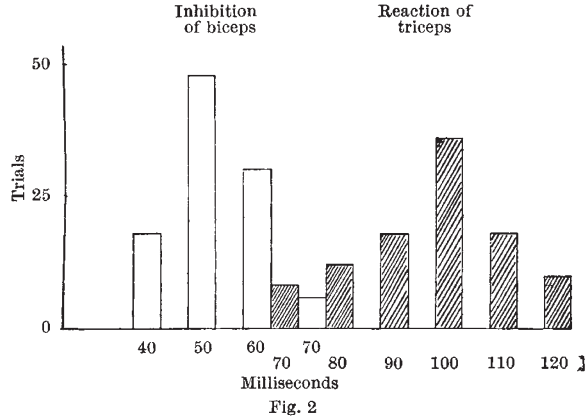

Fig. 2

M. biceps and triceps of the same arm were separately recorded by means of an electroencephalogram apparatus (Schwarzer). The subject held his M. biceps in strong tonic contraction and reacted to the sensory stimulus by a contraction of his M. triceps.

With this arrangement, the voluntary reaction of triceps contraction was usually preceded some 50 m.sec. earlier by inhibition of the tonic biceps contraction (Fig. 1). Fig. 2 shows in diagrammatic form the reaction times for antagonist inhibition and agonist contraction. The reaction time for antagonist (biceps) inhibition may be as short as 40 m.sec.—a surprisingly low value if the reaction is accepted as being cortically integrated (voluntary). The antagonist reaction could scarcely be an example of spinal reciprocal inhibition[3]; it is interpreted by us as part of the voluntary reaction, although the actual inhibitory influence may be exerted at the cortical or spinal level.

The afferent conduction time from the peripheral nerve to the sensory-motor cortical area has been estimated as about 18 m.sec. (after Dawson[4]). The efferent conduction time, from the motor cortex to the peripheral muscle, has been estimated as at least 12 m.sec., due regard being taken to interneuronal spinal transmission (Lloyd[5], cf. ref. 6). By subtraction, an interval of only 10–20 m.sec. is left for cortical integration of the reaction of antagonist inhibition. This time interval is of the same order of magnitude as the duration of an 'evoked potential'[7].

The present observations therefore indicate that even a voluntary sensory-motor reaction may take place within restricted cortical fields without necessarily engaging more complicated cortical or subcortical reverberating circuits.

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