Jose Delgado's "Physical Control of the Mind"

Evaluation of Electrical Control of the Brain

Because the brain controls the whole body and all mental activities, ESB could possibly become a master control of human behavior by means of man-made plans and instruments. In previous sections we have described methodology for brain stimulation and many effects evoked by ESB. This section will discuss the meaning of these results, the mechanisms involved, the expected limitations, and the problems facing investigators. How physiological or artificial is the electrical activation of neurons? How predictable? Who is responsible for acts performed under ESB-the stimulated subject or the scientist? Which benefits or risks may be expected in the future? Can we modulate perception and expression by electrical means? Can we expect that brain investigation will provide a new conception of the human mind? These and other questions confront the investigator while he is sending radio messages to induce a muscle to contract, a heart to beat faster, or a sensation to be felt. Evaluation of these experiments requires the formulation of appropriate theoretical concepts and the design of working hypotheses.

Brain Stimulation Triggers Physiological Mechanisms

Electrical stimulation of the brain is in reality a rather crude technique based on the delivery of a monotonous train of pulses without modulation, without code, without specific meaning and without feedback to the pool of neurons which by chance is located within the artificial electrical field created by stimulation. Temporal and spatial characteristics and the complexity of multisynaptic relays, delays, and convergent and divergent correlations are also absent. The intensity of several volts usually employed in ESB is hundreds of times higher than spontaneous neuronal potentials, which are measured in millivolts.

It is reasonable, therefore, that doubts have been expressed about the normality of responses obtained by brain stimulation. It is difficult to compare normal behavior with electrically evoked effects, considering the complications of operative trauma, artificiality of experimental conditions, and lack of specificity of ESB (4). "Electrical stimulus, unlike physiological excitation, unselectively affects all elements of a similar threshold that lie within the radius of action of the electrodes" (107), and in the majority of cases cortical stimulation "has failed to elicit anything but fragments of skilled Movements" (224). Cobb (33) considers the greatest oversimplification the belief "among those not educated in physiology, that the electrical stimulation of a nerve or brain center closely resembles normal

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neuronal stimulation. Electrical stimulation, however, produces little that resembles the normal."

It is certainly true that many responses evoked by ESB are simple contractions of a small group of muscles without coordination, skill, or apparent purpose, and that many effects have abnormal characteristics far removed from the harmonious elegance of voluntary activities. It is also true, however, that with the development of technology to stimulate the brain in free subjects, many of the responses obtained in both animals and man are indistinguishable from spontaneous behavior. Sequential behavior, sexual activity, alimentary responses, walking, yawning, fighting, and many other effects documented in previous sections demonstrate conclusively that ESB can evoke purposeful, well-coordinated, skillful activities of great refinement and complexity. Patients have accepted evoked psychological changes, such as an increase in friendliness, as natural manifestations of their own personality and not as artificial results of the tests. The question to answer is not whether but how the application of a crude train of messageless electricity may result in the performance of a highly refined and complicated response.

To explain this apparent contradiction we Must consider the normal mechanisms of physiological performance. In a simple act such as the flexion of a limb, the nerve impulse initiates a very complex process which includes well-organized, sequential, metabolic activities and structural changes in the myoproteins resulting in the shortening of muscle fibers. These processes do not depend on neural impulses and have been established by genetic determination as intrinsic properties of muscular tissue unfolding in a similar way under nervous command or direct electrical excitation. Electricity does not create muscle contraction; it simply activates a pre-established pattern of response. At the neurological level, flexion of a limb requires the propagation of many well-organized impulses from the brain to the different groups of muscles, the processing of proprioceptive information from many regions, the adjust-

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ments of servomechanisms, visceral adaptations, and many other electrical, thermal, chemical, mechanical, and physiological -established phenomena and correlations. The applied electricity is only the depolarizing trigger of a group of neurons; it starts processes which once activated are relatively independent of the initial cause. Evoked behavior is like a chain reaction in which the final result depends more on the structure and organization of the components than on the trigger. To understand the role of electrical stimulation, we may ask whether the finger of the person pushing a button to launch a man into orbit is responsible for the performance of the complicated machinery or for the sequence of events. Obviously the finger, like a simple electrical stimulus, is only the trigger of a programed series of interdependent events and cannot be accepted as the real cause of capsules orbiting around the earth.

A tentative explanation of some of the mechanisms involved in motor activities has been proposed in the theory of fragmental representation of behavior (53) which postulates that behavior is organized as fragments which have anatomical and functional reality within the brain, where they can be the subject of experimental analysis. The different fragments may be combined in different sequences like the notes of a melody, resulting in a succession of motor acts which constitute specific behavioral categories such as licking, climbing, or walking. The theory may perhaps be clarified with one example. If I wish to take a cookie from the table, this wish may be considered a force called "the starter" because it will determine the initiation of a series of motor acts. The starter includes drives, motivations, emotional perceptions, memories, and other processes. To take the cookie it is necessary to organize a motor plan, a mechanical strategy, and to decide among several motor choices, because the cookie may be taken with the left or right hand, directly with the mouth, or even by using the feet if one has simian skills. Choice, strategies, motor planning, and adjustments depend on a set of cerebral structures, "the organizer," which is different from the set employed by the starter, because the desire for

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cookies may exist in hungry people or in completely paralyzed patients, and the hands can move and reach the table for many different reasons even if there are no cookies. Finally, the actual contraction of muscles for the performance of the selected movement to reach the cookie-for example, rising the right hand-depends on a cerebral set, "the performer," different from the previous two, because motor representation of hands, mouth, and feet is situated in different areas of the brain, and the choice of muscle group to be activated is under the supervision of a given organizer. Naturally, there is a close correlation among these three basic mechanisms, and also between them and other cerebral functions. The concept of a brain center as a visible anatomical locus is unacceptable in modern physiology, but the participation of a constellation of neuronal groups (a functional set) in a specific act is more in agreement with our present knowledge. The functional set may be formed by the neurons of nuclei far from one another, for instance, in the cerebellum, motor cortex, pallidum, thalamus, and red nucleus, forming a circuit in close mutual dependence, and responsible for a determined act such as picking up a cookie with the right hand.

If we accept the existence of anatomical representation of the three functional sets - starter, organizer, and performer is logical that they can be activated by different types of triggers, and that the evoked results will be related to the previous experiences linked to the set. The same set, evoking a similar behavioral response, may be activated by physiological stimuli, such as sensory perceptions and ideations, or by artificial stimuli, such as electrical impulses. When we stimulate the brain through implanted electrodes we can, depending on the location of contacts, activate the starter, the organizer, or-the performer of different behavioral reactions, so that natural and artificial stimuli may interplay with one another, as has been experimentally demonstrated.

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