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The Emotions: Focus on Inter-Male  
Aggression and Dominance Systems  
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**AGGRESSIVENESS, HIERARCHY, AND RHYTHMS IN MONKEYS**

by

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**Discussion Paper**

on

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Aggressive behavior is heterogeneous in its causality, neurological mechanisms, and observed manifestations, but some elements are shared by all forms of aggression, including the need for sensory inputs, neuronal activation, and release of preestablished patterns of emotional and motor responses. Understanding and prevention of aggression require the simultaneous study of its genetic, social, cultural, and economic aspects at parity with an investigation of its neurological bases. Codes of information, frames of reference for sensory perception and for evaluation of threats, and formulas for aggressive performance in general are not established genetically but must be learned individually. Human beings are born with the capacity to learn aggressive behavior but not with established patterns of violence. Mechanisms for fighting, which are acquired by individual experience, may be triggered in a similar way by sensory cues, volition, and by electrical stimulation of specific areas of the brain.

To investigate the neurological mechanisms of aggressive behavior, the phenomenon may be considered a sequence of interrelated events requiring (a) reception of sensory inputs; (b) processing of the received information by means of cerebral throughputs; (c) triggering of emotional reactivity; and (d) expression of motor outputs resulting in social conflict.

In a monkey colony, peaceful relations may last until the occurrence of events such as the delivery of food which may trigger aggression. It should be remembered that the chemical mechanisms of muscle contraction are not specialized for aggression: the same movements may be used in different activities such as grooming, walking, or attacking. We may ask whether the neurological mechanisms involved in hostile

acts are specific or are shared with other types of behavior. In the working hypothesis of "fragmental behavior" (Delgado, 1964,1967,1969) we postulated that each behavioral category is formed by a series of motor fragments which have anatomical and functional representation within the brain. In food intake, the successive acts cannot be considered specific of alimentary behavior because the animal may orient itself toward different stimuli, may use its limbs for many purposes, may swallow water or simply salivate if it is anxious, and may bite during playing or fighting. The combination of successive acts and their aim together constitute the specific category of alimentation.

Aggression can be analyzed in a similar manner. Single behavioral fragments may form part of many categories and therefore they have a different significance in each context. Fragments of behavior may have a functional affinity, forming a sequence like the notes of a melody. This linkage is reinforced by use and weakened by disuse. Emotional behavior, including rage, is expressed by a variety of autonomic, somatic, and behavioral phenomena which may be shared by non emotional manifestations. Fear, for example, produces increased heart rate comparable to the tachycardia induced by other emotions or by non emotional exercise. Motor performance is related to kinetic formulas learned through past experience and modified by individual skills. An enraged person may display aggressive behavior but performance and efficiency will be very different if he is a sedentary professor or a jujitsu champion. It is highly improbable that motor activities have multiple cerebral representation only because they may be used for many purposes. It is more likely that the same cerebral mechanism is activated for the performance of similar motor acts which form part of different behavioral sets.

The theory of fragmental representation postulates that motor performance of behavioral fragments depends on a set of cerebral structures which is different from the set responsible for coordination of these fragments, for example, for a harmful purpose. The elements forming each behavior category should be studied separately to determine the cerebral representation of each fragment and to identify the brain areas which coordinate and integrate these elements. Depending on the site of cerebral stimulation, it should be possible to elicit isolated fragments of responses without purpose or context; or, alternatively, to elicit well organized, purposeful behavioral sequences. It should also be possible to modify hostility in a selective way without changing other aspects of individual reactivity.

Extensive studies in monkeys supports the above mentioned theory. As described in detail elsewhere (Delgado, 1967), different facial expressions and vocalizations, which appeared as isolated fragments of aggression, have been evoked in the same animal by electrical stimulation of points 5 mm apart in the nucleus olivaris superior, lateral lemniscus, nucleus reticularis, superior part of the nucleus reticularis, and superior colliculus. Facial expression of aggression has been induced by stimulation of the brain stem without offensive or defensive behavior. This response could not be conditioned, had no positive or negative reinforcing properties, and did not modify social behavior in the monkey colony.

In another series of experiments (Delgado and Mir, 1969), fragmental responses ranging from closing the ipsilateral eye (amygdala stimulation) to vocalization (fimbria stimulation) were characterized by their lack of purpose and adaptation, being generally stereotyped in contrast with other responses evoked by pedunculus cerebellaris medius

excitation which evoked complex, well organized aggression requiring skillful performance and adaptation to the location and reactions of the target animal.

Activation of the cerebral areas involved in the onset and organization of aggression may be secondary to the reception of nociceptive stimuli, or may be related more directly to the activation of primary cerebral representation of aggressive behavior. One location of these primary structures could be the hypothalamus. Most brain stimulation has produced only secondary aggressive responses.

One characteristic of electrically evoked aggression is the normality in processing of sensory information and the perfect adaptation to changes in the environment during performance of induced behavior. As previously suggested (Delgado, 1975), brain stimulation probably activates an "aggressive drive" in these cases because the offensive intent is constant whereas strategies and motor activities vary. This aggressive drive may depend on a set of cerebral structures that are activated directly in "primary" aggression or "secondarily" when nociceptive perceptions evoke an alarm, inducing escape from a potentially harmful stimulus or attack to remove the danger.

Aggression evoked by brain stimulation is indistinguishable from spontaneous hostilities, indicating that electricity triggers preexisting physiological mechanisms that interact with information from the environment. This hypothesis is supported by results of experiments in a monkey colony in which social hierarchy was manipulated (Delgado and Mir, 1969). Female monkey Lina was tested in three colonies where she ranked lowest, next to lowest, and finally was #2 below the boss. Ranking was evaluated by priority in food getting, territoriality, and the number and direction of threats and aggressive acts. In each colony, Lina was radio stimulated in the nucleus postero-

lateralis of the thalamus with the same parameters (100 Hz, 0.5 msec, 0.3 mA). In Colony I where Lina ranked lowest, these stimulations induced considerable increase in attacks against her, whereas in Colony III when Lina ranked #2, the same stimulations resulted in a marked increase in her attacks against other monkeys. This experiment demonstrated the essential role of social rank in the expression of aggression evoked by brain stimulation, since excitation of the same cerebral point produced different effects, even with opposite social consequences, depending on the hierarchical position of the test animal.

Similar results were produced in pairs of monkeys (Plotnik et al., 1971), stimulating monkey "A6" in a nociceptive region (nucleus corporis geniculate medialis) when in the company of a dominant or submissive animal. When "A6" was dominant, it attacked the submissive partner following stimulation, whereas in the company of a dominant monkey, the same cerebral excitations induced grimacing and submissive gestures in "A6" and this reaction often caused it to be attacked by the dominant animal.

In these studies, brain stimulation induced effects depending on the social structure of the group. Responses were not blind or stereotyped but were well integrated with other behavioral determinants. The performance of secondary aggression should have longer latency and more flexibility than primary aggression, in which triggering of hostility can be evoked out of context, inducing animals to appear hostile to a dominant partner regardless of its previous experience and personal risk. Responses of primary aggression have been evoked by stimulation of the hypothalamus: for example, false rage in cats (Delgado, 1964) and attacking by submissive monkeys (Alexander and Perachio, 1973) which disrupted and even reversed group ranking. Permanent reversal of dominance was also reported by Robinson et al. (1969)

following aggressive behavior induced by stimulation of the lateral and anterior hypothalamus in monkeys. In experiments with cats attacking anesthetized rats (Flynn, 1974), stimulation of the lateral hypothalamus elicited affective attack resembling behavior induced by tail shock which was evaluated as being related to nociception, whereas medial hypothalamic stimulation evoked quiet biting without emotional or hunger components which resembled predatory behavior.

Pharmacological studies in monkeys have also demonstrated the importance of individual and social variability in the evaluation of psychoactive drugs (Delgado et al., 1976). As a model, the effects of oral administration of Diazepam were tested in rhesus monkeys in three situations: (1) alone, (2) paired with a dominant partner, and (3) paired with a submissive animal. Spontaneous mobility of the test animal was similar in all three situations, demonstrating its independence of social conditions. Diazepam reduced mobility markedly when the animal was submissive. Food intake of automatically delivered pellets decreased significantly from situations (1) to (3). Some other behavioral categories were also closely related to social rank. Small oral doses (0.1 - 0.3 mg/kg) of Diazepam had significant effects on the behavioral profile only when the animal was submissive. When dominant, 0.1 mg/kg of Diazepam decreased the monkey's aggressive acts by 50% but doses as high as 10 mg/kg did not cause a reversal of dominance. These studies indicate that social status is of great importance in the behavioral effects of psychoactive drugs.

Hierarchy also plays an important role in the rhythmicity of spontaneous behavior, as shown in monkey colonies where animals were instrumented for continuous telemetric recordings up to 48 hours of EEG, EOG, EMG, mobility, and behavior. Each test animal was placed in different colonies

where its social status was high, medium, or low. Results showed that in the low agonistic situation, Stage 1 sleep was displaced to midday, while in the medium and high agonistic situation, it was displaced to night time. REM appeared to have some correlation with subsequent aggressive manifestations. Rank was more important during the day than during the night as a factor influencing characteristics of wakefulness and sleep stages (Fernández-Gonzalez and Delgado, in preparation).

The hope is often expressed that research on animal aggression may provide clues for the understanding and prevention of human hostilities. This may be accomplished in specific medical cases but it is doubtful that increased knowledge per se can directly affect social and ideological aggression, including terrorism and war. These conflict situations are caused by learned behavior inculcating the intent to cause injury. Cultural sensory inputs, learned codes, and preferential paths for action leave neuronal traces which can be studied experimentally. Research on the neurological bases of aggression should be closely related with the analysis of its genetic, social, cultural, and economic aspects. The prevention of human hostilities is not dependent on the organization of motor performance but on the neurological traces of hates and ideological conflicts which trigger the destructive application of learned behavior.



REFERENCES

- Alexander, M. and A.A. Perachio The influence of target sex and dominance on evoked attack in rhesus monkey. Amer. J. Phys. Anthropol., 38:543-548, 1973.
- Delgado, J.M.R. Free behavior and brain stimulation. Pp. 349-449 in: "International Review of Neurobiology," Vol. VI, C.C. Pfeiffer and J.R. Smythies (Eds.), New York: Academic Press, 1964.
- Delgado, J.M.R. Social rank and radiostimulated aggressiveness in monkeys. J. nerv. ment. Dis., 144:383-390, 1967.
- Delgado, J.M.R. "Physical Control of the Mind: Toward a Psychocivilized Society," Vol. XLI, World Perspectives Series, New York: Harper & Row, 280 pp., 1969.
- Delgado, J.M.R. Inhibitory systems and emotions. Pp. 183-204 in: "Emotions - Their Parameters and Measurement," L. Levi (Ed.), New York: Raven Press, 1975.
- Delgado, J.M.R., C. Grau, J.M. Delgado-García, and J.M. Rodero Effects of Diazepam related to social hierarchy in rhesus monkeys. Neuropharmacol., 15:409-414, 1976.
- Delgado, J.M.R. and D. Mir Fragmental organization of emotional behavior in the monkey. Ann. N.Y. Acad. Sci., 159:731-751, 1969.
- Flynn, J.P. Experimental analysis of aggression and its neural basis. Pp. 53-61 in: "The Neuropsychology of Aggression," R.E. Whalen (Ed.), Vol. 12 in "Advances in Behavioral Biology," New York: Plenum Press, 1974.
- Plotnik, R., D. Mir, and J.M.R. Delgado Aggression, noxiousness and brain stimulation in unrestrained rhesus monkeys. Pp. 143-221 in: "Physiology of Aggression and Defeat," B.E. Eleftheriou and J.P. Scott (Eds.), New York: Plenum Press, 1971.
- Robinson, B.W., M. Alexander, and G. Bowne Dominance reversal resulting from aggressive responses evoked by brain telestimulation. Physiol. Behav., 4:749-752, 1969.

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