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K.E. Moyer. Kinds of Aggression and their Physiological Basis, Communications in Behavioral Biology, Part A., Vol. 2, No. 2, August 1968. 65-87.

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The term aggression is usually applied to behavior which leads to, or appears to an observer to lead to, the damage or destruction of some goal entity. However, the stimulus situations which elicit destructive behavior and the patterns of behavior that result in damage and destruction are so diverse that it appears clear that there must be a variety of physiological substrates involved. It therefore seems fruitless to search for the physiological basis of aggression.

Several authors have suggested that aggression is not a unitary concept. To date, however, there has been no systematic attempt to sort out the various kinds of aggression and indicate a reasonable basis for classification. Those are two objectives of this paper.

If, as suggested here, there are several kinds of aggression, progress in understanding the general phenomenon

of aggressive behavior can only be made when the various aggressions are carefully and operationally defined. The definition phase must then be followed by research in which experimental manipulations are applied to the subjects and they are then tested in a variety of situations which define the various classes of aggression. A given manipulation may very well facilitate one kind of aggression, suppress another and have no effect on a third.

1. Scott, J.P. Aggression. Chicago, Ill. University of Chicago Press, 1958. p.vii
2. Bevan, W., W.F. Daves and G.W. Levy. The relation of castration; androgen therapy and pre-test fighting experience to competitive aggression in male C57 BL/10 mice. Anim. Behav., 8, 6-12, 1960.
3. Jacobsen, E. The clinical effect of drugs and their influence on animal behavior. Revue de Psychologie Appliquee, 11, 421-532, 1961.
4. Valzelli, L. Drugs and aggressiveness. Advances in Pharmacology, 5, 79-108, 1967.

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The classes of aggression here defined are predatory, inter-male, fear-induced, irritable, territorial defense, maternal and instrumental.



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There are some obvious differences in the response patterns that animals show in different aggression inducing situations. Several authors have pointed out<sup>1,2,3</sup> that the topography of behavior in predatory attack by the cat is quite different from a type of aggression which has been called 'affective' aggression, however, there is evidence of pronounced sympathetic arousal. The back arches, the tail fluffs out, the ears lay back against the head, the animal hisses and growls and may attack in a flurry of scratching and biting. Tinbergen<sup>4</sup> has said that deer use their antlers when engaged in conflict with other male deer (inter-male aggression) but use their front hooves in defense against predators. When more detailed ethological analyses have been done, response topography may become a useful method of differentiating among the various kinds of aggression. At this point, however, the observations are too limited to permit a general classification on this basis.

1. Wasman, M. and J.P. Flynn. Directed attack elicited from hypothalamus. Arch. Neurol. 6, 220-227, 1962.
2. Roberts, W.W. and H.O. Kiess. Motivational properties of hypothalamic aggression in cats. J. Comp. Physiol. Psychol., 58, 187-193, 1964.
3. Hutchinson, R.R. and J.W. Renfrew. Stalking attack and eating behavior elicited from the same sites in the hypothalamus. J. Comp. Physiol. Psychol. 61, 300-367, 1966.
4. Tinbergen, N. Fighting and threat in animals. New Biology, 14, 9-24, 1953.

not induce a non-killer to attack a mouse but it does



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- K.E. Moyer. Kinds of Aggression and their Physiological Basis, Communications in Behavioral Biology, Part A., Vol. 2, No. 2. Academic Press Inc., August 1968. 65-87. p.66

1) **Predatory aggression** This type of aggressive behavior is evoked by the presence of a natural object of prey. Movement on the part of the prey, though not essential, increases the probability of attack. Predatory aggression is differentiated from the other classes of aggression by its relative stimulus specificity and the general irrelevance of the particular test environment.

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- K.E. Moyer. Kinds of Aggression and their Physiological Basis, Communications in Behavioral Biology, Part A., Vol. 2, No. 2. Academic Press Inc., August 1968. p. 65-87 . p.67

2) **Inter-male aggression** The most potent releaser of this aggressive response in most species is the presence of a male conspecific to which the attacker has not become habituated. The general environment in which the stimulus is presented is not particularly important and the attack is made without provocation on the part of the victim. Inter-male aggression is differentiated from the other classes on the same basis as indicated for predatory aggression.

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3) **Fear-induced aggression** In its purest form, fear-induced aggression is always preceded by attempts to escape, thus, one of the components of the stimulus situation eliciting fear-induced aggression is a degree of confinement in which the defensive animal is cornered and is unable to escape. In that situation, the animal turns and attacks the attacker. A second component of the stimulus situation is, of course, the presence of some threatening agent. This type of aggression is differentiated from all others in that it is always preceded by escape attempts.

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Irritable-aggression: The stimulus situation which evokes an irritable aggression response is the presence of any attackable organism or object. The range of stimuli which will elicit irritable aggression is extremely broad, and may involve inanimate as well as animate objects. The epitome of this type of aggression is usually described as anger or rage. The fact that the general environment is not relevant to the evocation of irritable aggression differentiates it from territorial defense and maternal aggression. Irritable aggression is differentiated from fear-induced aggression in that it is not preceded by attempts to escape and therefore does not involve a "fear" component. Irritable aggression is differentiated from predatory and inter-male aggression by its inclusiveness. The animal showing irritable aggression will attack prey, other males and many other available stimuli. Predatory attack and inter-male attack, however, are limited to the relevant objects.

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Territorial defense: In this case, the stimulus situation involves an area in which the animal has established itself, and an intruder. A conspecific is most likely to be attacked but some species will attack an intruder of any type. The stimulus of the territory is essential to this class of aggression and differentiates it from other types. The attack is provoked simply by the presence of the other animal in the territory and the probability of attack decreases as the attacking subject gets further from its own territory.

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Maternal aggression: In most mammalian species this type of aggression is the particular province of the female. The stimulus situation involves the proximity of some threatening agent to the young of that particular female. Thus, both the young and the threatening agent are a part of the necessary stimulus complex and differentiates this class of aggression from the others. As the mother gets further from the young, the tendency to aggression decreases.

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Instrumental aggression: Any of the above classes of aggression may result in a change in the environment which constitutes a reinforcement for the animal with the consequent increase in the probability that the aggressive behavior will occur in a similar situation. This position is considered in detail in Feshbach's paper<sup>1</sup>. Instrumental aggression is a learned response and the stimulus situation which may evoke it can be any of those described above.

1. Feshbach, S. The function of aggression and the regulation of aggressive drive. Psychol. Rev., 71, 257-272, 1964.

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For the sake of completeness, it should at least be mentioned that sex related aggression is probably also a class of aggression. These are the aggressive responses which are elicited by the same stimuli which produce sexual response. The existence of sex related violence is obvious to anyone who reads the newspaper but very little is known about the variables of which it is a function. There is some experimental evidence to show that sexual and aggressive motivation are related. Since little more is known about this class of aggression, it will not be discussed further.

1. Barclay, A.M. and R.N. Haber. The relation of aggressive to sexual motivation. J. Personality, 3, 462-475, 1965.

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Wasman and Flynn (1962)<sup>1</sup> and Egger and Flynn<sup>2</sup> differentiate qualitatively between predatory attack and 'affective attack' in the cat. If the animal is stimulated in the area of the lateral hypothalamus it will ignore the experimenter and attack a rat. However, if the stimulation is in the medial hypothalamus, the cat will ignore a rat and attempt to attack the experimenter. They also report that the topography of the two types of response is different in that predatory attack involves only 'minimal signs indicative of feline rage'. A number of other studies have also shown that stimulation of the lateral hypothalamus of the cat produces predatory aggression.<sup>3-7</sup>

Stimulation in the lateral hypothalamus of the rat does

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not induce a non-killer to attack a mouse but it does reduce the killing latency of a natural killer<sup>8</sup>. Predatory attack in the cat induced by hypothalamic stimulation is augmented by the simultaneous activation of the midbrain reticular formation either through direct electrical stimulation or by the administration of amphetamine,<sup>10</sup>

1. Wasman, M. and J.P. Flynn. Directed attack elicited from hypothalamus. Arch. Neurol., 6, 220-227, 1962.
2. Egger, M.D. and J.P. Flynn. Effect of electrical stimulation of the amygdala on hypothalamically elicited attack behavior in cats. J. Neurophysiol. 26, 705-720, 1963.
3. Hutchinson, R.R. and J.W. Renfrew. Stalking attack and eating behavior elicited from the same sites in the hypothalamus. J. Comp. Physiol. Psychol., 61, 300-367, 1966.
4. Roberts, W.W. and H.O. Kiess. Motivational properties of hypothalamic aggression in cats. J. Comp. Physiol. Psychol., 58, 187-193, 1964.
5. Levison, P.K. and J.P. Flynn. The objects attacked by cats during stimulation of the hypothalamus. Anim. Behav. 13, 217-220, 1965.
6. Wasman, M. and J.P. Flynn.... 1966
7. MacDonnell, M.F. and J.P. Flynn. Attack elicited by stimulation of the thalamus of cats. Science, 144, 1249-1250, 1964.
8. Karli, P., M. Vergnes and F. Didiergeorges. Rat-mouse interspecific aggressive behavior and its manipulation by brain ablation and brain stimulation. Paper presented at the First International Symposium on Aggression, Milan, Italy, 1968.
9. Sheard, M.H. and J.P. Flynn. Facilitation of attack behavior by stimulation of the midbrain of cats. Brain Res., 4, 324-333, 1967.
10. Sheard, M.H. The effects of amphetamine on attack behavior in the cat. Brain Res., 5, 330-338, 1967

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**Predatory aggression:** Predatory responses are aggressive in that they lead to the injury or destruction of the prey. Aside from that, predatory aggression has little in common with the other classes of aggression listed above.<sup>1, 2</sup> The physiological basis of predatory aggression in mammals has been most extensively studied in the cat and the rat, and experimental evidence is rapidly accumulating to indicate that the neurological basis of this kind of aggression is distinct from that of other kinds.

1. Delgado, J.M.R. Aggressive behavior evoked by radio stimulation in monkey colonies. Amer. Zool. 6, 669-681, 1966.



2. **Carthy, J.D. and E.J. Ebling.** The Natural History of Aggression. New York: Academic Press, 1964.

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Hunger is evidently not essential for the manifestation of predatory behavior since many predators will continue to kill long after their capacity to eat the prey has been exceeded, and will kill even when satiated. However, it is still possible that the same factors which influence eating behavior also influence predator behavior. Food deprivation in the killer or in the hypothalamically stimulated predatory may shorten the killing latency, or lower the required stimulation threshold. The experiments to test this hypothesis have not yet been done.

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In summary, the evidence seems to lead to the conclusion that predatory aggression can be differentiated from other forms of aggression on the basis of both the topography of the response, and the relatively specific stimulus situation which will elicit it. The physiological mechanisms underlying predatory aggression also appear to be different from those underlying other types of aggression.

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In summary, inter-male aggression appears to be elicited by a relatively narrow range of sensory stimuli and is inhibited by specific sensory stimuli. It is particularly dependent on the male hormone for its manifestation. Thus, the evidence indicates that inter-male aggression can be characterized as a relatively unique class which can be differentiated from other classes of aggression on a variety of dimensions.



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In summary, it appears that the stimulus situation which produces fear-induced aggression can be readily differentiated from that which produces other types of aggression. Although little research has been directed specifically toward this problem, the literature seems to indicate that the neurological basis of this class of aggression is different from that of predatory aggression and that further research will differentiate it from irritable aggression as well as other types. Little is known about the endocrine basis of this type of aggression.

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Irritable aggression: In its pure form irritable aggression involves attack without attempts to escape from the object being attacked. The most extreme form of irritable aggression is exemplified by destructive 'uncontrollable rage' directed against either animate or inanimate objects. In less extreme forms, it may involve only 'annoyance' or half hearted attack.

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In summary, irritable aggression can be reasonably well differentiated from the other classes of aggression discussed. States of the organism which are sufficient to produce it are frustration, increase in drive and pain. The ventromedial hypothalamus and the medial nucleus of the amygdala are particularly involved as a part of the neurological basis of this class of aggression although stimulation and lesions in other areas of the brain have also produced it. It can also be inhibited by brain stimulation and lesions. Although the endocrine experiments do not provide clear cut answers, there is little doubt that a variety of endocrine dysfunctions alter the organism's tendencies to irritable aggression.

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Diandrone (dehydro-isoandrosterone) has been shown to increase confidence in adolescents with feelings<sup>1</sup> of inferiority and to promote aggressive responses. In patients with a history of aggressiveness, diandrone is likely to produce excessive irritability and outbursts of rage.<sup>2,3</sup>

1. Sands, D.E. and G.H.A. Chamberlain. Treatment of inadequate personality in juveniles by dehydroisoandrosterone. Brit. Med. J., 66-68, 1952.
2. Strauss, E.B., D.E. Sands, A.M. Robinson, W.J. Tindall and W.A. Stevenson. Use of dehydroisoandrosterone in psychiatric treatment. Brit. Med. J. 64-66, 1952.
3. Sands, D.E. Further studies on endocrine treatment in adolescence and early adult life. J. Mental Sci. 100, 211-219, 1954.

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**Territorial aggression:** Relatively little space will be devoted to this class of aggression because virtually nothing is known about the physiology involved.

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**Maternal aggression:** Although many animals are capable of intense aggression in defense of the young<sup>1</sup> little is known about the physiology of this class of aggression. ~~Incidental~~

1. Hafez, E.S. The behaviour of domestic animals. Baltimore, Maryland: Williams and Wilkins, 1962.



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Instrumental aggression: This class of aggression does not have a particular definable physiological basis, except as learning and reinforcement have a physiological basis. It consists merely of the increase in tendency for an organism to engage in destructive behavior in a particular situation because that behavior has been reinforced in the past. If the particular situation involves another animal, the cue complex of that animal tends to elicit aggressive responding.

1. Feshbach, S. The function of aggression and the regulation of aggressive drive. Psychol. Rev., 71, 257-272, 1964.

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Interactions among the classes of aggression: The discussions above have dealt with the classes of aggression in their pure form as much as possible in order to attempt to clarify the underlying physiological bases. There is every reason to believe, however, that the different kinds of aggression interact with each other, and differentially with other drive states. For example, in an excellent paper by Baenninger it was shown that a learned fear response and pain have a differential effect on predatory aggression in the rat. A conditioned emotional response was developed in mouse killing rats by giving them tone-shock trials. Testing the rats in the presence of a mouse showed that the conditioned stimulus of the tone inhibited mouse killing but the unconditioned stimulus of shock overcame the inhibition and produced killing. This appears to be the interaction of predatory and irritable aggression.

over



1. Baenninger, R. Contrasting effects of fear and pain on mouse-killing by rats. J. Comp. Physiol. Psychol. 63, 298-303, 1967.

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It appears that irritability and thus the tendency to irritable aggression is increased by any stressor. Whether all of these antecedent causes for irritable aggression can be subsumed under the general term 'frustration' as argued by Berkowitz is a semantic problem.

As indicated in the discussion of fear-induced aggression, it is frequently difficult to determine from experiments designed to deal with other problems what particular kind of aggression is being observed. It is therefore not possible to delineate with any confidence the neurological basis of irritable aggression. There are, however, a number of experiments from which tentative conclusions may be drawn.

1. Berkowitz, L. Aggression+ A social psychological

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It is trite to say that more research is needed. More research is always needed. In this case, however, more research is needed soon. Aggressive behavior is one of the critical problems facing man. Whether it is the collective aggressive tendencies that lead nations to war, or the irritability of a mother who slaps her child without justification, aggressive tendencies are significant contributors to the unhappiness of man. It seems only reasonable to assume that the much predicted population explosion is going to lead to an explosion in inter-personal aggressiveness. One of the principal things to be learned from the study of increases in population density in animals is that aggressive behavior increases with the rise in population.<sup>1-3</sup> Thus, there are practical and urgent as well as scientific reasons for an increase in attention to this problem.



1. Guhl, A.M. Gonadal hormones and social behavior in infra-human vertebrates. In W.C. Young and G.W. Corner (Eds.) Sex and Internal Secretions. Baltimore, Maryland: Williams and Wilkins, 1240-1267, 1961.
2. Thiessen, D.D. and D.A. Rodgers. Population density and endocrine function. Psychol. Bull., 58, 441-451, 1961.
3. Christian, J.J. and D.E. Davis. Endocrines, behavior and population. Science, 146, 1550-1560, 1964.

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Interpretation of the above findings must remain tentative until further research is done which recognizes the different types of aggression and tests for them specifically while manipulating the particular amygdaloid nuclei. It does not appear possible to reconcile the results of all of the studies done on the amygdala, but several points seem to stand out. Fear-induced, irritable, and predatory aggression are probably controlled by separate but overlapping anatomical areas. Fear-induced is, in general, located more dorsal, lateral and rostral, whereas irritable is more ventral, medial and caudal. Predatory aggression control is located in the more dorsal portion of the amygdala.

It also seems likely in the light of the results of Fonberg, Woods<sup>2</sup>, and Egger and Flynn<sup>3</sup> that a portion of the amygdaloid area controlling fear also has inhibitory functions

in relation to the irritable and predatory areas. There is no indication at the moment whether the inhibition acts through the facilitating areas of the amygdala or whether it functions through the lower brain areas.

1. Fonberg, E. Effect of partial destruction of the amygdaloid complex on the emotional-defensive behavior of dogs. Bull. Acad. Polon. Sci. 13, 429-431, 1965.
2. Woods, J.W. 1958
3. Egger, M.D. and J.P. Flynn. Further studies on the effects of amygdaloid stimulation and ablation on hypothalamically elicited attack behavior in cats. In Adey and Tokizane (Eds) Progress in Brain Research, Vol. 27, Elsevier, Amsterdam, 1967.

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The physiological bases of aggressive behavior have been reviewed and the concept has been developed that aggression is not a unitary phenomenon. There are several kinds of aggression each of which has a particular neural and endocrine basis. The types of aggression may be classified on the basis of the stimulus situation which will elicit it. Although the classes of aggression may overlap, different experimental manipulations will differentially affect the various kinds. These classes of aggression and what is known about the neurology and endocrinology of each are briefly summarized below.

Predatory aggression is elicited by a narrow range of stimuli. The topography of the response is different from that for other types of aggression. The lateral hypothalamus is particularly involved in predation. Predatory aggression is inhibited by amygdalotomy and probably facilitated by

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frontal lesions. It is little influenced by either the presence or absence of gonadal hormones.

Inter-male aggression is elicited by a strange male of the same species and is inhibited by particular 'submissive' postures of that male. It is particularly dependent on the male hormone for its development. Little is known about the neural basis of this class of aggression except that the septal area is probably involved.

Fear-induced aggression occurs only in cases where escape has been attempted but is not possible. In general, it is reduced by lesions in the septum and ventro-medial nucleus of the hypothalamus. It is increased by stimulation in the hypothalamus anterior to the ventro-medial nucleus. Little is known about the endocrinology involved.

Irritable aggression may be increased by frustration, deprivation, and pain. The ventro-medial hypothalamus is particularly involved and paradoxically, irritable aggression is increased by either stimulation or ablation of that area. It is reduced by amygdectomy, castration, and stimulation of the caudate nucleus and the septum. A wide range of stimuli will elicit irritable aggression.

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Territorial aggression and Maternal aggression both appear to be specific to the situation involved and what little evidence there is indicates that the reproductive hormones are involved. Essentially nothing is known about the neural basis of these kinds of aggression.

Instrumental aggression may be based on any of the above classes. It consists of an increase in the tendency for an organism to engage in destructive behavior when that behavior has been reinforced in the past.

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The literature on the effect of population density on the pituitary-adrenal axis has been well summarized<sup>1,2,3</sup>. Increased adrenal weight, and evidently increased adrenal function, co-vary with increased irritable aggression under the pressure of greater population density. The casual relationship among these variables is not yet clear. Fighting is a stressor and must, therefore, influence endocrine changes. Thus many of the glandular changes which occur are likely to be the result of fighting as suggested by Scott.<sup>4</sup> It also seems likely, however, that the hormonal changes resulting from stress sensitize those brain areas which are related to irritable aggression. This hypothesis, however, has not been tested experimentally.

There are a number of suggestions from clinical endocrinology which implicate endocrine mechanisms in irritable

aggression. - It seems that irritability may result from any significant disturbance of the endocrine balance<sup>5</sup>. Increases in irritability result from hypo and hyperfunction of the adrenal cortex as well as from hypo and hyperthyroid states.<sup>7</sup>

1. Guhl, A.M. Gonadal hormones and social behavior in infra-human vertebrates. In W.C. Young and G.W. Corner (Eds.) Sex and Internal Secretions. Baltimore, Maryland: Williams and Wilkins. 1240-1267, 1961.
  2. Thiessen, D.D. and D.A. Rodgers. Population density and endocrine function. Psychol. Bull., 58, 441-451, 1961.
  3. Christian, J.J. and D.E. Davis. Endocrines, behavior and population. Science, 146, 1550-1560, 1964.
  4. Scott, J.P. Agonistic behavior of mice and rats. A review. Amer. Zool., 6, 683-701, 1966
  5. Reiss, M. Psychoendocrinology. J. Mental Sci., 100, 211-219, 1954.
  6. Cleghorn, R.A. Steroid hormones in relation to neuropsychiatric disorders. In H. Hoagland (Ed.) Hormones, - Brain Function and Behavior. New York: Academic Press, 1957
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7. Gibson, J.G. Emotions and the thyroid gland. J. Psychosomatic Res., 6, 93-116, 1962.

2.

from this should remain open. There is no doubt that Pithecanthropus of the Pekin Caves half a million years ago ate the brains of his fellow men; but, as one of the speakers said, these may have been men of the same species yet of neighbouring groups. How can we tell? Even at this early time level must we rule out the possibility of ritualized behaviour? The earliest use of what were probably missile stones was not long after the beginning of hunting, perhaps a million years ago or more. The oldest evidence of the use of wooden spears is from deposits of the Second Interglacial age (2 quarter of a million years ago). There was no organized warfare before the Neolithic period, beginning less than 10,000 years ago.

Huxley: I have recently seen an extraordinary film made by Osmond, Hoffer and Fogd, which showed drastic personality changes produced by hypnotically induced changes in perception. Thus a suggested brightness



of all colours tended to a hypnomanic state, with rather aggressive behaviour, while suggested inability to perceive any colour produced a depressive state. The most remarkable effects were produced by altering the time-sense. When this was too much speeded up, the subject became violently aggressive and truly manic. When "time was made to stop" (by stopping the metronome which the subject had been told would beat at the rate of one per second), the subject became catatonic with Waxy-flexibility.

Further experiments have shown that when two persons are put together who have received the suggestion that they would see everything in the same colour (e.g. blue), they tend to be amicable; whereas when two persons are put together who have received the suggestion that they would see everything in different colours (e.g. one in blue, the other in red), they tend to quarrel and to become aggressive towards each other.

