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Biological Bases of the Aggressive Behaviour

S. Giammanco, G. Tabacchi, D. Di Majo, M. Giammanco, M. La Guardia

Istituto di Fisiologia e Nutrizione Umana. Università di Palermo

The aggressive behaviour is common to all animal species, at least from fish onwards. It can be defined as the execution of actions, from threatening gestures to real attacks - addressed to animals belonging to either the same or a different species. The study of the physiological mechanisms laying behind this behaviour is supported by methods based on either ablation or stimulation of some determined brain structures. This is a really useful approach in order to establish which pathways and nerve centres are involved in the aggressive behaviour (mesencephalon, hypothalamus, amygdala, Papez circuit).
The stimulation of a cat's mesencephalon periaqueductal grey substance induces an aggressive behaviour towards either a mouse or a rat. This region receives afferences from the hypothalamus and is connected to the sensitive and motorial areas of the mesencephalon. In animals with isolated hypothalamus, the electric stimulation of the periaqueduct grey substance induces aggressive - although less intense - behaviours, even if a higher intensity of stimulation is needed, compared to intact animals. In animals treated with a section of the brainstem slightly below the mesencephalon, it is possible to observe non-coordinated movements belonging to the sequence of aggressive behaviour. In fact, the sequence of movements which represent the expression of aggressiveness is organised just at the level of mesencephalon. The electric stimulation of the hypothalamus induces different aggressive behaviours, depending on the stimulated hypothalamus area. It is possible to distinguish a «hot», emotional aggressiveness from a «cold», apathetic (privative a, + patos = emotion), unemotional aggressiveness. The first one is induced by a stimulation of the dorsal and the medial hypothalamus; the other one is induced by a stimulation of the lateral hypothalamus. The emotional aggressiveness is a very intense expression; animals assume a position which is specific of their own breed (as an example, the cat arches its back) and show their teeth; there are strong signs of activity of the ortosympathetic system. The attack is launched with striking ferocity, as if the animal flied into a rage or should desperately defend itself from a real dangerous enemy. This behaviour is usually (but not always) addressed to animals of the same breed (intraspecific aggressiveness). The unemotional aggressiveness is significantly different since it is not accompanied by any emotional involvement (myosis, and not mydriasis). The animal is perfectly lucid, it has really much more chance to kill the other animal; it ceases the attack as soon as the other animal stops moving. It is similar to a predatory attack. This kind of attack is always addressed to animals belonging to a different breed (interspecific aggressiveness). The difference between these two kinds of behaviour is also evident when we consider the way how the attacks are launched. As an example, a cat attacks another cat (intraspecific aggressiveness) using its clutches, while a rat (interspecific aggressiveness) is killed by a bite on the neck: the motorial patterns are completely different. Another important difference is that, if we put the animal in the condition of making switch on and off the brain stimulation leading to an attack (such as by pushing two different levers), it soon learns how to stop an emotional attack, but does not stop pushing the lever for the stimulation of the «cold» attack. This makes us think that the «hot» attack is a negative experience for the animal, while the «cold» one is considered enjoyable.
The electric stimulation of the amygdala produces essentially emotional attacks and fear reactions; the mostly interested nuclear group is the basolateral one. Lesions in this area tend to suppress (but they do not eliminate) the emotional behaviours connected to emotional attacks and fear reactions. When hypothalamic lesions are present, the effects of the stimulation of the amygdala are either absent or delayed.
Later on, thanks to the evolution of the knowledge in Physiology and Pharmacology of the Central Nervous System, researchers have focused their interest on the importance of neurotransmitters and neuropeptides in the induction and inhibition of these behaviours. Among all of them, a primary role is undoubtedly played by serotonin: every physiological or pathological condition exerting an influence either on the levels of serotonin in the nervous centres involved in the aggressive behaviour, or on the affinity for its numerous receptors (around 15), or else on its postreceptorial effects, is able to either reduce or inhibit aggressiveness both in laboratory animals and in man. Around 2/3 of the non-killer adult rats (interspecific aggressiveness) become killer after only three days of tryptophan-free diet [1]. The interruption of the proencephalon serotoninergic ways promotes the aggressive attack in rats [2]. A lower latency and a higher intensity in the attack against an intruder in their cage was observed in mice «knock out» as for the gene codifying the serotoninergic receptor 5 HT 1B. A number of studies performed on non-tamed and free Rhesus monkeys, have showed that low levels of 5-hydroxyindolacetic acid (a serotonin catabolite whose high levels are considered as an index of high activity of

serotoninergic neurons) found in their cerebrospinal fluid (the monkeys are catched in order to collect samples of fluid and then they are set free) are connected to a higher inclination to face an eccessive risk, such as fighting against elder and stronger males [3]. In man, low levels of 5-hydroxyindolacetic acid are connected to aggressive and antisocial behaviour. The administration of serotonin-agonists (fluoxetin) reduces the levels of aggressiveness. Among all the endogenous molecules favouring the onset of an aggressive behaviour through a reduction of the serotoninergic systems activity, testosterone plays a fundamental role. According to a classic notion of Physiology, the aggressive behaviour is more frequent in males and it can also be totally abolished by castration [4]. During the growth, testosterone «moulds» the brain in a «male» direction (by either inducing or blocking apoptosis in different brain areas); this has not only neuroendocrinal, but also behavioural functional effects [1]. Testosterone receptors are localised in a number of different brain areas, in particular in the medial preoptical area of the hypothalamus. It has been observed that androgens reduce serotonin brain levels and modulate the genic expression of some receptors [5]. A more thorough knowledge of the interactions between the great number of different hormones and neurotransmitters and the large number of serotonin receptor subtypes will allow us to better understand the molecular mechanisms conditioning the aggressive behaviour.

Key words

Aggressive behaviour, serotonin, testosterone, hypothalamus

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