Aggression – is it genetically or environmentally caused?

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Why are men considered more aggressive than women? How come adolescent boys so irritable and moody? A high testosterone level is known to increase levels of aggressive behaviour but is it, the only causative attribute? Aggression generally is considered an unpleasant antisocial behaviour whose sole purpose is to cause harm, or, a tool for asserting dominance in social situations. Behavioural analysts consider it as a symptom rather than a disorder because it usually an outcome of many neurological disorders and brain- injury related dysfunctions. Nevertheless, just like any other complex human trait, there more that meets the eye when understanding aggressive behaviours in humans. Several twin and adoption studies warrant that many genes other than the ones involved with testosterone are also involved, but genetics is not the only culprit. It has an accomplice – the environment.

What is aggression?

Aggression can be defined as a maladaptive and escalated form of anger to the point of causing harm not only to other individuals but also to one's self. It is only in recently that researchers have considered the possibility of genes being an underlying factor in understanding violent behaviours among convicts. There are generally two major forms of human aggression: proactive and reactive. Proactive aggression is the kind that looks premeditated and deliberate, with neither regret nor remorse being expressed. Reactive aggression is characterised by excessive emotional sensitivity and often triggered by anger, anxiety and negative life experiences. It appears overrated from the exaggerated response individuals have, since they lack the ability to control their own emotional status.

Like any other emotion, aggression is regulated by highly conserved brain structures that are part and parcel of the limbic system. Any dysfunction in the limbic system's circuitry might become an etiological factor that results to violent behaviour as studied extensively in animal behavioural laboratory models. Other than that, server damages to other brain regions such as the frontal and temporal lobes can cause the same effect.

The limbic system

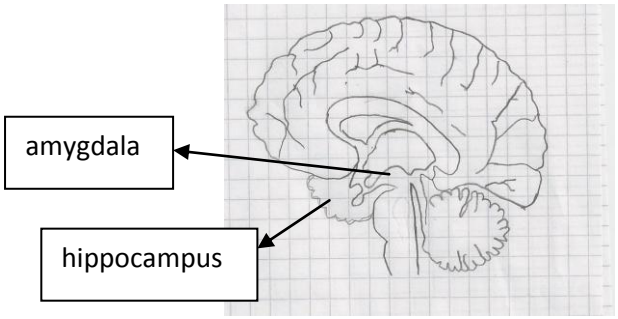

Fig 1. The limbic system

The limbic system is a collection of nuclei that are regulate emotions. It mainly structures such as the amygdala and the hippocampus. Amygdala serves a collection centre for all sensory input and thereby controlling the neural circuitry that trigger emotional response.

Even if the idea of aggression being advantageous is not palatable all, it serves a purpose from an evolutionary perspective it serves many purpose in the open wild, for instance; in instilling social hierarchy/dominance, facilitating mating successes, fending for resources and from predators. In fact, the most common forms of aggression are territorial and predator related. That is why a weaning female wildebeest will not be afraid to defend its calves from hungry lion.

The genetics of aggression

Statistical probability that aggression is allelic based is as high as 50% in various twin studies, under the conditions that it is a progressive state from childhood to adulthood. The heritability aspect of human aggressive behaviour lies upon the interplay between the neurotransmitter mechanisms and the endocrine system. Neurological implications to aggression are mostly related to the neurotransmitter systems of serotonin, noradrenalin, dopamine and GABA; duly because they play an active role in the regulating hormones. Hormonal imbalance in the case of testosterone will negatively impact behaviour, by increasing the propensity towards aggression. However aggression is more than that – it a result of the inhibitory mechanism failing to control aggression aggregating factors. For instance, higher testosterone levels will lead to aggressive dispositions while activation of substances such serotonin facilitates the inhibition mechanism that reduces/controls anger. Therefore, in regards to testosterone/serotonin ratios, it has been proven that low serotonin activity, in conjunction with high testosterone levels enhances aggressive dispositions in humans.

The serotonergic pathway

Serotonin (5HT) is of particular interest because it does not only limit aggressive behaviours, it also mediates a wide range of cognitive functions including food seeking, sexual behaviours

and depression. It mediates its functions via its own receptors, and in addition, the receptors themselves offer a great deal in understanding how aggression can be genetically motivated. Serotonin is mostly produced in the brain stem via the enzymatic activity of tryptophan hydroxylase (TPH) from its amino acid precursor tryptophan. The *TPH* gene is a candidate for behavioural studies because of its polymorphic variants are not only considered genetic markers for aggression but also for suicidal tendencies. One particular gene variant is strongly associated with temperamental impulses because individuals, who have it, tend to luck the capability to control their rage.

Noradrenaline (NA) and nueropetide Y (NPY)

Noradrenaline is the precursor to adrenaline and also synthesized in the brain stem. Studies have shown that noradrenoline's receptor is a causative factor for aggression especially in amphetamine addicts because of its high affinity to amphetamines and amphetamine related substances. NPY was first discovered as neuro-peptide that regulated appetite and funny enough; when we get hungry we become grumpy! The focus of NPY from food to aggression was facilitated by observing territorial aggression in male mice whereby, they would actually kill other trespassing mice.

The Dopaminergic pathway

Genetic variants that are associated with the hyper-stimulation of dopaminergic system related to depression and schizophrenia disorders have also been held accounted for aggressive dispositions also. Dopamine as a neurotransmitter is produced in a region just outside the limbic system. Pathological aggression tendencies are believed to be caused by decrease in dopamine sensitivity in the brain's reward system. The receptors here too, which are of two sub-types, have been used as genetic markers for aggression. They of interest because; (1) they remove of dopamine from the synaptic cleft and lastly but not least and (2) they regulate neurotransmission feed-back mechanism. Allelic variant of these receptors have been sadly identified with aggression in adolescents, and hence religiously used to predict delinquent involvement in children.

Monoamino oxidase A and B (MAO A & MAO B)

These are a group of enzymes whose main function is to degrade neurotransmitters after a chemical synaptic event. Therefore any disruption in this system will impact the degradation processes of most if not all neurotransmitters. Genes of *MAO-A* and *MAO-B* are located in the X-chromosome. *MAO-A* genetic forms have proven invaluable in the study of human behaviour because of the risk for anxiety related disorders especially in women and antisocial tendencies among certain alcoholics. Furthermore, behavioural observations in animal study have revealed that mice without *MAO-A* gene are more aggressive than the normal ones. Translate this principle to humans, aggressiveness in regards to *MAO-A* defects are mostly due to point mutations whereby, these mutations abolish the catalytic functions of the whole *MAO-A* gene.

A well known study case involving male individuals in certain a Dutch family has secured *MAO-A* candidacy in hot spot. The aggression dispositions and violent behaviours in these men, was beyond extreme given that they are capable of attacking their own female relatives. Such studies based on familial cases prove that *MAO-A* gene defects are carried by the female

germ line. Interestingly, MAO-A's enzyme activity in female carrier does not differ from non-carrier females because women have two X-chromosome, and if one chromosome bears a defect gene, the other copy on the other chromosome will take over. But in men, if the X-chromosome has a defective gene, its effect cannot be masked.

Aggression- a social maladjustment or genetically mediated?

One cannot deny the role hormones play in sexual maturation during puberty, and how unpleasant it becomes dealing with testosterone-filled boys. However, the link is not that simplistic. Testosterone, just like any other hormone relies on other mechanisms to fulfil its functions. Serotonin and oestrogen hormone have crucial roles in the testosterone mechanism – they reduce aggressiveness by affecting testosterone centres in the amygdala and hippocampus.

Even though twin-studies show that genetics role as causative factor for negative behavioural tendencies is as high as 50% one cannot rule out the environment. In normal circumstance, anger and irritation are used as tools to indicate to the outside world that something is not as it should be. However it is the individual differences that make aggression all more interesting given that, it is the levels of aggression that become a problem; not the trait itself. Offensive behaviours characterised by neurological disorders and brain injuries have proven that aggression is rather a syndrome than a disorder. In other words, aggression is a mismatch product between perceived stimuli and response, whereby a slight provocation can result to an extreme a reaction. Nevertheless, a person's environment is important because it where the stimuli originates from.

More information

More detailed information can be found in the following articles:

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Konstamtin PA, Christiakov DA, Chekhonin VP. 2012. Genetic determinants of aggression and impulsivity in humans. Journal of Applied Genetics **53:**61-82.