Effect of hormones on aggressive behaviour

The role of hormones in mediating aggressive behaviour

How hormones can trigger and influence aggression in animals and humans has interested many researchers in the last six decades (Brooks-Gunn, Graber, & Paikoff, 1994). Scientists realised soon that aggressive behaviours has to be always set in a larger context. The larger context can never be neglected while investigating complex human behaviours. This applies especially when considering the hormonal contributions to aggressive behaviour since far more than one link seems to exist between hormones and aggression. For instance, the hormonal control of parental, sexual and reproductive behaviour crucially determines aggression in both humans and animals. Parents of many animal species are increasingly aggressive while experiencing hormonal changes, for example, during lactation and parturition as they strive to defend their offspring from enemies (Beach, 1979). The aim of this paper is to evaluate the study on hormones and aggressive behaviour in the evolutionary context. Nonetheless it is not intended to conceptualise this evolutionary context without relation to other domains such as the social or cognitive one as these domains are inextricably linked. “ A developmental perspective of aggression thus is based on the assumption that aggressive behavior is multidetermined and dynamic over the life span, and a product of a complex continuous interaction of the multiple psycho-bio-social changes.” (Ramirez, 2003; p. 622).

Aggression

The fact that multiple modulators for aggression seem to exist makes it more difficult to reach conclusions. An additional problem is that the usage of the word aggression is too broad and there is yet not consensus over how it can be actually defined (Kavoussi, Armstead, & Coccaro, 1997). Aggression has been predominantly related to an emotional state that individuals frequently describe as involving a strong drive to inflict harm and emotions of disregard and hate. However, overt aggression comes, in contrast to the described inner feeling of hate, in different forms. Predatory aggression, for instance, refers to the feeding behaviour of animals and is represented by attacks directed at natural prey. It has been demonstrated that the majority of vertebrates display aggression between two males of the same species while only some animals display maternal aggression. Fear-induced aggression, on the other hand, appears when an animal is anxious and/or incapable to escape from a perceived dangerous situation. Irritable aggression, however, comes frequently close to uncontrollable rage and is triggered by immense pain or frustration (Rosenzweig, Breedlove, Reiman, 2002).

Nelson (1995) reported how male sex hormones play a significant role in various forms of aggressive behaviour like for example in within-species social interactions and encounters. As a consequence, aggressive behaviour between males increases on the verge to sexual maturity. Experiments with male mice have demonstrated that their aggressiveness levels rise significantly during puberty while immature mice display more violent behaviours against each other when they are treated with androgens (McKinney & Desjardins, 1973).

Puberty and Hormonal Change

Given the dramatic changes that occur in endocrine physiology at puberty, it is not surprising that increases in testosterone are hypothesized to be related to increases in aggression. This explains why testosterone has been the most investigated hormone in its research. The wealth of evidence supporting the ability of testosterone to facilitate aggressive behaviour in a broad number of mammal species has led to wonder about its potential role in human aggression. Wingfield and colleagues (1987) were among those researches who successfully demonstrated that the amount of displayed aggression in many species is related to the amount of seasonal testosterone change.

Yet experiments with youths experiencing puberty yielded equivocal results. Book and collaborators (2001) for instance conducted a meta-analysis on 45 independent studies and came to the conclusion that the mean weighted correlation of these studies was only weakly positive (r = 0. 14). This finding was congruent with Archer’s (1991) meta-analyses as he had also found rather marginally significant positive relationships between testosterone levels in humans and aggression.

Experiments investigating the on the effects of castration on subjects illustrated more convincingly how inextricably aggressive behaviour is linked to hormones. Conclusively, castrated males displayed less aggressive behaviour due to the decreased androgen production. If, in turn, testosterone is injected into these castrated species one can again observe an increase in inter-male violent behaviour. Females are less often studies by researchers with regard to hormonal affects on aggression. This is due to the fact that males engage significantly more often in aggressive behaviour

than females (e. g. number of male murderers is five times higher in the United States). Thus the predominant viewpoint among scientists is that males of most species are the more aggressive and violent sex. Consistently, recent research has found more support for a link between androgens and aggressive affect for boys entering puberty (Olweus et al., 1988) but less strong associations for girls (Paikoff & Brooks-Gunn, 1990). Nevertheless some studies found that in some species like Hamsters the female sex is more aggressive. However, this was not anymore the case when the female Hamsters entered the estrus stage.

As a matter of fact, not all studies have supported the notion that the amount of hormones, especially androgens, is negatively associated to aggression levels. Ehrenkranz and colleagues (1974) for example demonstrated that testosterone levels of humans were positively related to aggressiveness while Kreuz and Rose (1972) could not find a significant correlation between levels of testosterone and aggressiveness in prisoners. Nonetheless Dabbs and Morris (1990) maintained with the help of their study on military veterans that testosterone levels can be linked at least to violent antisocial behaviour. More recently Dabbs and Hargrove (1997) revealed that high testosterone levels are a remarkable characteristic and predictor of female prisoners who are convicted of self-initiated violent crimes.

At least two confounding variables exist

Research has also demonstrated the existence of at least two confounding variable which have a significant influence on the relationship between hormones and aggressive behaviour. Bernstein and Gordon (1971) showed

that both monkeys and mice who come out as winners of an aggressive interaction display increased testosterone levels whereas the losers experience a decrease in androgens. Consequently, the winners become more aggressive while the losers are less prone to exhibiting aggressive behaviour towards their own and other species. One could conclude that it was more a consequence rather than a cause that the more aggressive prisoners in Dabbs and Hargroves (1997) experiment had higher testosterone levels. Surprisingly not only the winners of aggressive encounters but also the triumphant of sport competitions experience observable increases in their testosterone levels. It goes further that this increase is not only experienced by those who actively participate and win in the sporting event but is even experienced by those who support and cheer up the winning side or individual (Bernhardt, 1997).

As even chess players display after having lost chess matches lower levels and after having won higher levels of testosterone it was concluded that another confounding variable mediates between aggression and testosterone because chess players are hardly aggressive in their normal behaviour.

Regardless of these confounding variables sexual assaulters, aggressors and criminals have been often castrated in the past in order to decrease both their sex and aggression drives. The results of these studies reported that criminals were less susceptible to aggressive behaviour after having experienced a decrease in sex hormones induced by their castration (Brain, 1994). Nowadays, however, ethical issues and concerns have become increasingly important and thus it is debatable and questionable whether

these kind of forced surgical interventions are ethically justifiable and tenable.

Serotonin and Aggressive Behaviour

The synaptic transmitter serotonin seems to have as well a profound impact on aggressive behaviour in both humans and animals. In contrast to testosterone, however, a negative association between aggression and brain serotonin activity has been reported in past studies. Higley and collaborators (1992), for instance, investigated the activity of the neurotransmitter serotonin in around 30 monkeys in an observational study. The researchers ranked the monkeys according to their aggressive activities on the island where they were freely living and compared their ranks with the amount of serotonin brain activity. Their results demonstrated that serotonin levels are negatively correlated with aggression. Virkkunen and Linnoila (1993) supported these findings with their own study. They showed that individuals who consume alcohol excessively have comparatively lower serotonin metabolites concentrations (e. g. HIAA concentrations) in their cerebrospinal fluid. These applied also to animal torturing children (Kruesi, 1979) and due to aggressive behaviour expelled American Marines (Brown et al., 1979). As a matter of fact, serotonin levels are affected by environmental context and stimuli. Dominant and high ranking primates for example who stand on the top of the hierarchical social status ladder display greater serotonin levels than primates who rank lower in the pecking order. If however the higher ranked primates loses his social status he analogously experiences a decrease in serotonin levels.

Testosterone and Aggressive Behaviour

Schaal and colleagues (1996) investigated more recently the association between physical violence and social dominance of pubescent male youths and their respective testosterone levels. It was shown that less socially dominant youths had lower levels of testosterone in comparison to socially more dominant peers who possess concurrently bigger amounts of testosterone amounts. Nevertheless, this finding could not be repeated with aggression levels as those pubescent youths who were perceived as more aggressively behaving had significantly lower testosterone concentrations than those males who had a low history of being physically aggressive and violent. Thus it was concluded that testosterone was related not so much to antisocial characteristics than to experienced social status. In other words, those who successfully achieve higher social dominance statuses experience an increase in testosterone while those who fail to gain high social status face a reduction in their testosterone production.

Experiments with younger children (e. g. 5-year-olds) it was found that boys with higher testosterone concentrations were more playfully aggressive in social interactions. However, this relationship could neither be established with girls nor in play contexts (Ahedo et al., 2002). This again implies that testosterone levels are not solely a modulator of aggressive behaviour but rather a mediator of any kind of social behaviour. Additionally, Ahedo and collaborators study demonstrated that sex differences in behaviour establish themselves already very early on in life.

In another study (van Goozen et al., 1998) the androstenedione, testosterone, dehdroepiandrostenedione (DHEA) levels in prepubescent boys exhibiting antisocial conduct disorders was examined. Van Goozen and colleagues results revealed that antisocial conduct disordered infants' aggressiveness was not significantly relatable to testosterone. However, the more antisocially behaving boys had significantly higher than average androstenedione levels and modestly higher than average DHEAS levels. Researchers like Ramirez (2003) believed that studies such as these have the power to shadow doubt on the validity of testosterone as a biological control system for aggressive behaviour in postnatal life. Even later on in life testosterone levels seem only to represent the consequence rather than a cause of aggression as testosterone does not immediately lead people to be physically aggressive but their aggression is solely a response to cognitive and social stimuli and triggers (Brain & Susman, 1996).

Studies on observed changes in concentration levels of testosterone and cortisol during aggressive behaviour and social stress serve as support for those researchers maintaining that both the evolutionary and social contexts and experiences have an essential impact on hormonal levels in humans. Thus " gonadal hormones, besides being only one of the multiple processes - biological, social, and cognitive, to influence aggression in children and adolescents, might also be a signal of aggression, or even more precisely perhaps, of social success." (Ramirez, 2003; p. 630).

These findings about serotonin and testosterone are according to Ramirez (2003) of utmost importance as they demonstrate that that experiences made in life can alter both brain chemistry and hormonal production in

fundamental ways. Thus it can be noted that social context and hormonal activities in the body and brain are inextricably linked.

Past researches on abnormal (van Goozen et al., 2000) and normal (Nottelmann et al., 1987; Inoff-Germain et al., 1988) male and female children have revealed univocal associations between high hormone levels of adrenal origin like androstenedione or dehydroepiandrostenedione sulphate and aggression together with diverse other negative attributes such as antisocial behaviour, rebelliousness and anger. Furthermore, the fact that androstenedione which is a prevalent producer of androgens is linked to anger in females suggests that adrenal and not gonadal originated androgens play a fundamental part in determining the aggressive behaviour of the female sex. In addition to that, it has been found that serotonin is not the sole mediator of aggression but also noradrenergic, neuropeptides and GABA systems have been demonstrated to have an impact on aggressive behaviour. Additionally, estrogens, gonadotrophins, and prolactine have been identified as minor modulators. Thus, genetic and pharmacological experts have essentially extended the number of relevant hormones and neurotransmitters in the last couple of years (Nelson & Chiavegatto, 2001).

In conclusion, all the above findings fortify and support the currently predominant notion that aggression is not mediated by only one factor but by a network of many interplaying variables.

References

Ahedo, L., Cardas, J., Aizpiroz, A., Brain, P. F., & Sanchez-Martin, J. R. (2002). Social behavior in male and female 5-year olds and its relation to salivary

testosterone levels. *The developmental origins of aggressive behavior* (p. 53). Montreal: ISRA.

Archer, J. (1991). The influence of testosterone on human aggression. *British Journal of Psychology, 82* , 1–28.

Beach, F. A. (1979). Aggressive Behavior. *Hormones and Aggression, 5(3)* , 313-316.

Bernhardt, P. C. (1997). Influences of serotonin and testosterone in aggression and dominance: convergence with social psychology. *Current Directions in Psychological Science, 2(6)* , 44-48.

Bernstein, I. S., and Gordon, T. P. (1974). The function of aggression in primate societies. *American Scientist, 62* , 304-311.

Book, A. S., Starzyk, K. B., & Quinsey, V. L. (2001). The relationship between testosterone and aggression: A meta-analysis. *Aggression and Violent Behavior, 6(6),* 579–599.

Brain, P. 1994. “ Hormonal aspects of aggression and violence.” In A. Reiss, Jr., K. Miczek, and J. Roth (Eds.), *Understanding and Preventing Violence* , Volume 2., pp. 173-244 Washington DC: National Academy Press.

Brain, P. F., & Susman, E. J. (1996). Hormonal aspects of antisocial behavior and violence. In D. M. Stoff, J. Maser, & J. Maser (Eds.), *Handbook of antisocial behavior* (pp. 314–323). Hillsdale: Laurence Erlbaum.

Brooks-Gunn, J. Graber, J. A., & Paikoff R. L. (1994). Studying links between hormones and negative affect: models and measures. *Journal of Research on Adolescence, 4(4)* , 469-486.

Brown, G. L., Goodwin, F. K., Ballenger, J. C., Goyer, P. F., et al. (1979). Aggression in humans correlates with cerebrospinal fluid amine metabolites. *Psychiatry Research, 1* , 131-139.

Dabbs, J. M., Jr., and Hargrove, M. F. (1997). Age, testosterone, and behaviour among female prison inmates. *Psychosomatic Medicine, 59* , 477-480.

Dabbs, J. M., Jr., and Morris, R. (1990). Testosterone, social class and antisocial behavior in a sample of 4. 462 men. *Psychological Science, 1(3)* , 209-211.

Ehrenkranz, J., Bliss, E., and Sheard, M. H. (1974). Plasma testosterone: correlation with aggressive behaviour and social dominance in man. *Psychosomatic Medicine, 36* , 469-475.

Higley, J. D., Mehlman, P. T., Taub, D. M., Higley, S. B., et al. (1992). Cerebrospinal fluid monoamine and adrenal correlates of aggression in free-ranging rhesus monkey. *Archives of General Psychiatry, 49* , 436-441.

Kavoussi, R., Armstead, P., & Coccaro, E. (1997). The neurobiology of impulsive aggression. *Psychiatry Clinic North America, 20(2),* 395–403.

Kreuz, L. E., Rose, R. M. (1972). Assessment of aggressive behaviour and plasma testosterone in a young criminal population. *Psychosomatic Medicine, 34* , 321-332.

Kruesi, M. J. (1979). Cruelty to animals and CSF 5HIAA. *Psychiatry Research, 28* , 115-116.

Inoff-Germain, G. E., Arnold, G. S., Nottelmann, E. D., Susman, E. J., Cutler, G. B., & Chrousos, G. P. (1988). Relations between hormone levels and observational measures of aggressive behavior of early adolescents in family interactions. *Developmental Psychology, 24* , 129–139.

McKinney, T. D., and Desjardins, C. (1973). Postnatal development of the testis, fighting behaviour, and fertility in house mice. *Biology of reproduction, 9* , 279-294.

Nelson, R. J. (1995). *Introduction to behavioural endocrinology* . Sunderland MA: Sinauer Associates.

Nelson, R. J., & Chiavegatto, S. (2001). Molecular basis of aggression. *Trends in Neurosciences, 24(12)* , 713–719.

Nottelmann, E. D., Susman, E. J., Dorn, L. D., et al. (1987). Developmental processes in American early adolescents: Relationships between adolescent adjustment problems and chronological pubertal stage and puberty-related serum hormone levels. *Journal of Pediatrics, 110* , 473–480.

Olweus, D., Mattsson, A., Schalling, D., & Low, H. (1988). Circulating testosterone levels and aggression in adolescent males: a casual analysis. *Psychosomatic Medicine, 50,* 261-271.

Paikoff, R. L., & Brooks-Gunn, J., (1990). Associations between pubertal hormones and behavioural and affective expression. *In* C. S. Holmes (Ed.), *Psychoneuroendoctrinology: brain, behaviour, and hormonal interactions* (pp. 205-226). New York: Springer-Verlag.

Ramirez, J. M. (2003). Hormones and aggression in childhood and adolescence. *Aggression and Violent Behavior, 8* , 621–644

Rosenzweig, M. R., Breedlove, S. M., Leiman, A. L. (2002). *Biological Psychology. MA* : Sinauer Associates.

Schaal, B., Tremblay, R. E., Soussignan, R., & Susman, E. J. (1996). Male testosterone linked to high social dominance but low physical aggression in early adolescence. Journal of the American *Academy of Child and Adolescent Psychiatry, 35(10)* , 1322–1330.

van Goozen, S. H., Matthys, W., Cohen-Kettenis, P. T., Gispen-de Wied, C., Wiegant, V. M., & van Engeland, H. (1998). Salivary cortisol and cardiovascular activity during stress in oppositional-defiant disorder boys and normal controls. *Biological Psychiatry, 43(7)* , 531–539.

van Goozen, S. H., van den Ban, E., Matthys, W., Cohen-Kettenis, P. T., Thijssen, J. H., & van Engeland, H. (2000). Increased adrenal androgen functioning in children with oppositional defiant disorder: A comparison with

psychiatric and normal controls. *Journal of the American Academy of Child and Adolescent Psychiatry, 39(11)* , 1446–1451.

Virkkunen, M., and Linnoila, M. (1993). Brain serotonin, type II alcoholism and impulsive violence. *Journal of Studies on Alcohol, 11* , 163-169.

Wingfield, J. C., Ball, G. F., Dufty, A. M., Hegner, R. E., et al. (1987). Testosterone and aggression in birds. *American Scientist, 75* , 602-608.