Role of Alcohol and Sex Hormones on Human Aggressive Behavior

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Summary

The promoting role of alcohol on human aggressive behavior is well established. This action may relate to the fact that alcohol is commonly consumed in situations where aggression in also initiated for other reasons: the reduction in the capacity to cognitively control the behavior or comprehend the situational context, facilitation due to expectancy factors, and effects on steroid hormone levels and other biological structures.

Positive associations have been reported between endogenous testosterone levels and both psychological and physical aggression in both men and women. Thus, possible effects of alcohol on testosterone levels are relevant for the expression of aggressive behavior. Recent investigations have demonstrated that alcohol may elevate testosterone levels in men, which may further affect aggressive behavior. In contrast, alcohol commonly elevates testosterone levels in women, especially during the use of oral contraceptives. This could have a major effect in promoting aggression in women under the influence of alcohol.

In comparison to androgens, little is known about the role of estrogens in human aggressive behavior. Recently, however, a positive association was demonstrated between plasma estradiol and emotional negotiation during interpersonal conflict situations. Furthermore, a negative association was observed between estradiol and testosterone-related physical, violent aggression in men with a history of alcohol-related aggression. On the other hand, estradiol, rather than testosterone, was positively associated with psychological aggression in both control men and in men with alcohol-related aggression.

The following conclusions may been drawn from the most recent studies: it seems that physical aggression itself is caused by factors other than testosterone but the underlying strength by which the aggression is expressed is related to testosterone.

Furthermore, endogenous female sex hormones may be related to empathic behavior and could, thus, represent a counter-balancing factor in alcohol-related male aggressive behavior. Overall, recent findings imply that estradiol-testosterone-related regulations may not only explain individual differences in men but may also explain part of the broader gender differences regarding empathic and aggressive behavior.

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Introduction

Human aggression is a complex behavior that involves a number of components that, in turn, are regulated by both psychosocial and biological factors. The present survey will focus on psychological and physical aggression, which may lead to injury-inflicting violence. These forms of aggression are initiated by situation-mediated feelings or emotions of anger, the strength of which is regulated by the comprehension of the situational context and underlying biological structures. The expression of anger into subsequent forms of aggression is in turn highly controlled by cognitive factors.

Both alcohol and sex hormones, especially androgens, are well known to be associated with aggressive behaviors in both men and women and, thus, the general aspects of these interactions will only briefly be discussed in the present work. Instead, the main aim of the present work is to review new data regarding the specific roles of testosterone and estradiol in the actions of alcohol-related aggression with special emphasis on the influence of alcohol and gender differences.

Alcohol and Aggression

Alcohol is well known to be associated with aggression, and several comprehensive reviews on this topic have been written (Boyatzis 1977; Brown and Witherspoon 2002; Bushman 1997; Bushman and Cooper 1990; Chermack and Giancola 1997; Giancola 2002; Langhinrichen-Rohling 2005; Kantor and Straus 1987; Leonard 2002; Milgram 1993; Taylor and Chermack 1993; von der Pahlen 2005). Naturally, one main social contextual reason for the association between alcohol intake and interpersonal aggression relates to the fact that alcohol is commonly consumed in situations and events where aggression is also initiated for other reasons, e.g., in alcohol-licensed establishments (pubs, bars, restaurants, etc), at sporting events and at other different types of gatherings, especially among the younger generation. With and without the combination of the preceding social factors, the other main explanations for alcohol-related aggression include the loss of cognitive capacity to control the behavior and to comprehend the situational context leading to aggression, as well as aggression-related alcohol expectancy. Thus, individuals with underlying general dispositions for aggressive behavior would be especially susceptible to such actions of alcohol. (Fig. 1)

The anxiolytic and stimulatory effects of alcohol have also been proposed to explain alcohol-related aggression (Blanchard et al. 1993; Phil et al. 1993). These and other more direct effects of alcohol on the regulation of aggressive behavior have been associated with the GABA, neurosteroid and monoamine systems (Lavine 1997; Miczek et al. 1997, 2003).

Testosterone and Aggression

Androgens, especially testosterone, have been firmly established to promote aggression (at least in some form and in some conditions) in a number of animal species (Albert et al. 1992; Giammanco et al. 2005; Hau 2007; Sluyter et al. 1996; Soma 2006). However, regarding humans, the positive association between aggression and testosterone has mostly, albeit not absolutely consistently, been documented in correlation

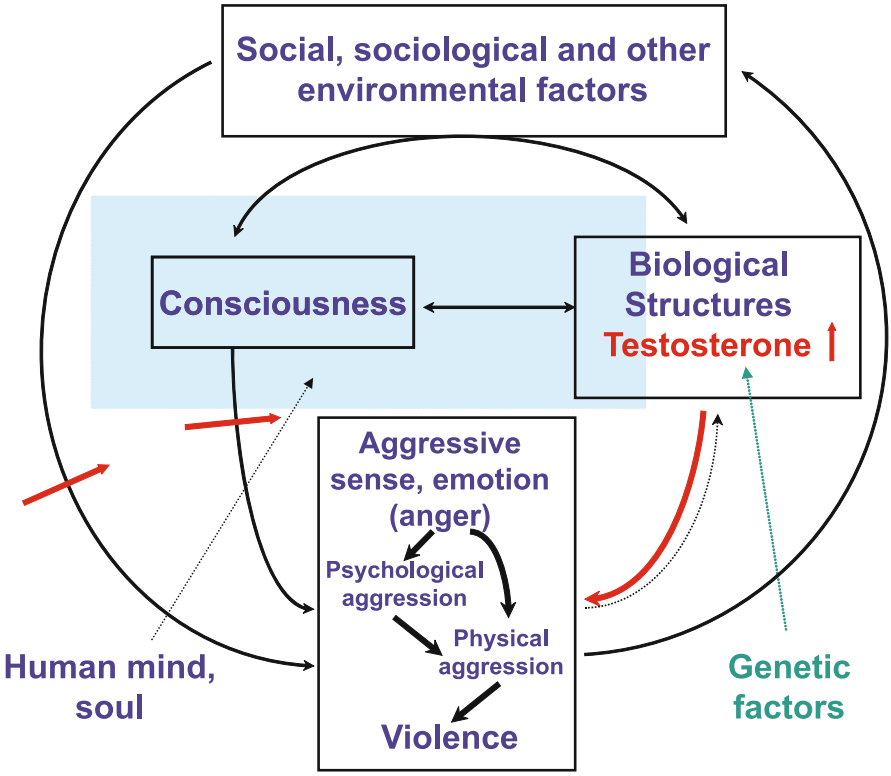

Fig. 1. The role of alcohol in the sociobiological regulation of aggression. The sites of alcohol actions are marked in red. Alcohol may promote aggression by the facilitation of social context-associated aggression, reduction of cognitive comprehension and control, and by the elevation of testosterone levels

studies involving both cross-sectional and selected populations and in group comparison studies usually comparing control and delinquent populations (Archer 1991, 2006; Christiansen 2001; Rubinow and Schmidt 1996, von der Pahlen 2005; Zitzmann and Nieschlag 2001). Also, objections to the meaning of the positive correlation between circulating testosterone levels and aggressive behavior have been raised based on observations of testosterone elevations as a consequence of aggression (Archer 1991; Christiansen 2001; Zitzmann and Nieschlag 2001). Although this effect may explain some of the positive associations, it seems unlikely that it would be the whole explanation for these relationships.

Intervention studies with exogenous testosterone administrations have displayed both significant (Finkelstein et al. 1997; Hermans et al. 2007; Kouri et al. 1995; Pope et al. 2000; van Honk et al. 2001) and non-significant (Anderson et al. 1992; O'Connor et al. 2002, 2004; Tricker et al. 1996; Yates et al. 1999) signs for, at least, prerequisites of aggressive behavior. One problem with the intervention experiments is that giving external testosterone immediately results in the cessation of the natural production of testosterone as a consequence of the feedback inhibition system. Thus, periodical

testosterone elevations may have been followed by subsequent testosterone losses, which may have blurred the overall behavioral outcome. Without careful monitoring and determination of the circulating testosterone levels, which is the case in most of the above-mentioned studies, it is hard to evaluate the intervention results. The poor results from intervention studies may also be explained by the possibility that testosterone levels are only promoting aggression and the real situational reasons for initiating aggressive behavior have been lacking in some these studies.

Alcohol, Testosterone and Aggression

It is a challenging possibility that, by affecting testosterone homeostasis, alcohol could affect aggressive behavior. Two early studies showed no significant effects of alcohol on testosterone levels in male occasional drinkers (Ylikahri et al. 1978) and alcoholics (Huttunen et al. 1976). Other early studies displayed alcohol-mediated testosterone reductions with moderate to high alcohol doses in non-alcoholic men (Bertello et al. 1983; Dotson et al. 1975; Gordon et al. 1978; Mendelson et al. 1977, 1980; Rowe et al. 1974; Välimäki et al. 1984; Ylikahri et al. 1974). However, it has more recently been demonstrated that alcohol may also elevate testosterone levels in men during the intoxication (Sarkola and Eriksson 2003), which would fit with the notion of a promoting effect on aggressive behavior.

In contrast, alcohol commonly elevates testosterone levels in women, especially during the use of oral contraceptives (Eriksson et al. 1994; Frias et al. 2000, 2002; Sarkola et al. 2000, 2001). This could have a major effect in promoting aggression in women under the influence of alcohol.

An overall path-model of the proposed sociobiological regulation of alcohol and testosterone-mediated aggressive behavior is presented in Fig. 1. It is rather obvious that the high degree of alcohol intoxication constitutes a far too common condition during which the ratio between senses and sensibilities is too high for an individual to prevent the derivation and expression of regrettable aggression.

Role of Estradiol in Alcohol- and Testosterone-related Aggression

Early Findings on Estradiol and Aggression

An early review of aggressive behavior in hamsters (Floody and Pfaff 1974) concluded that endogenous estradiol facilitates aggressive behavior in females and that exogenous estradiol facilitates aggressive behavior in castrated males and in ovariectomized females. On the other hand, it was also concluded that exogenous estradiol may counteract male behaviors by interference with production, activity or both of testicular androgens. A later review concluded that the essential hormones for full manifestation of aggression in female rats appear to be both testosterone and estradiol (Albert et al. 1992). More recently, in line with previous conclusions, it was reported that estradiol itself, in addition to testosterone, may produce aggressive behavior also in male birds

(Wingfield et al. 2001). Finally, an elaborate study using CYP19 knockout male mice with an inborn lack of the aromatase P450, which is responsible for the conversion of androgens to estrogens, demonstrated that there was an absolute requirement for exogenous estradiol during the neonatal stages of life for the development of the potential for aggression observed in adulthood (Toda et al. 2001).

In comparison to androgens and the results on experimental animals, almost nothing has been reported about the role of estrogens in human aggressive behavior. Originally, estrogens were used with some success to suppress violent sexual aggression, but their use has been limited because of side effects such as nausea, vomiting, and feminization (Bradford 1983). The discussion about these and other ethical problems regarding this form of current "voluntary" treatment of sexual offenders continues (Berlin 2003).

Estrogen treatments of aggressive behavior in both male and female geriatric patients have resulted in some improvements, especially regarding sexual and physical aggression (Kyomen et al. 1991; Kay et al. 1995; Lothstein et al. 1997; Shelton and Brooks 1999; Wiseman et al. 1997). It is notable that no improvements were achieved regarding the suppression of verbal aggression (Kyomen et al. 1991; Shelton and Brooks 1999). Another problem may be the rebound aggression effect after the treatment (Hall et al. 2005). The overall benefits of this form of treatment are yet to be evaluated.

Estrogens have also been linked to empathic behavior in a study in which fatherhood elevated estradiol levels, post-birth compared with pre-birth, or compared with controls (Berg and Wynne-Edwards 2001). The results were interpreted as possible signs of paternal responsiveness.

Recent Findings Regarding the Relative Roles of Testosterone and Estradiol in Alcohol-related Aggression

Recently in Finland, a case-control study was performed in which a randomized male population (AGG−) was compared with men having a history of alcohol-related aggression (AGG+; Eriksson et al. 2003). The aim of the study was to explore the relationship between aggression and endogenous testosterone and estradiol levels. The CTS2 (revised Conflict Tactics Scale; Straus et al. 1996), which in addition to scales for psychological and injury-inflicting physical aggression contained scales for emotional negotiation, was chosen as the primary validated questionnaire.

The results were the following: 1) endogenous testosterone levels (adjusted for estradiol variation) correlated significantly positively with physical aggression and injury-inflicting violent aggression in the AGG+ group, but no significant correlations were found with psychological aggression and with the emotional negotiation scores in both groups of men; 2) although no significant group differences in testosterone levels were observed between the two groups of men, the injury-inflicting behavior occurred only at elevated testosterone levels in the AGG+ men; 3) endogenous estradiol levels (adjusted for testosterone variation) correlated significantly positively with psychological aggression and with emotional negotiation in the control group; and 4) in spite of no group differences in testosterone levels, significantly lower (about 25%) estradiol levels were detected in the violent AGG+ compared with the AGG− men.

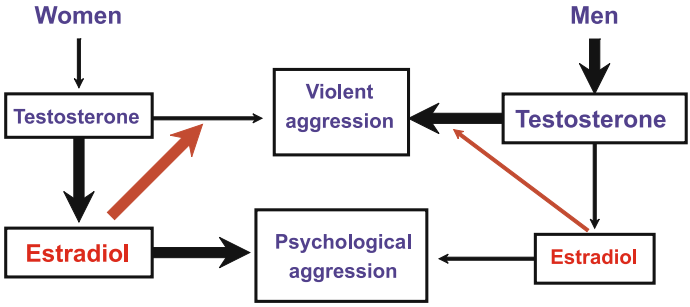

Fig. 2. The role of testosterone and estradiol in human aggression in a broader gender perspective. Red arrows depict inhibitory actions that may involve altruistic mechanisms

Conclusions

Testosterone is more likely to provide the underlying force for physical aggressive behavior than being the instigator of this behavior. Likewise, estradiol may provide the force for psychological aggression.

Earlier results on testosterone associations with less violent forms of aggression need to be re-evaluated for the possible role of estradiol. The dissection of aggression into components, and the use of estradiol as a covariate, will be helpful in producing reliable future studies on the relationship between testosterone and aggression.

Estradiol counteracts testosterone-related violent aggression in men and probably also in women. This effect may be related to estrogen-related altruistic behavior.

The present estradiol-testosterone results may not only explain individual differences in men but may also account for part of the broader gender differences regarding empathic and aggressive behavior (see path-model in Fig. 2).

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