Developing effective behavioral and psychological mechanisms for coping with social stress was very important in human evolution because humans evolved as social beings. The aggressive and post-aggressive behavior of 30 boys aged 7–11 years was observed during free play in summer camp with the standard “post-conflict—matched control” method (de Waal and YOshihara, 1983). The focals were the victims of the conflict. Saliva samples for examination of cortisol and dehydroepiandrosterone sulfate levels were taken from each boy in 5 cases: 10 minutes after a conflict with and without reconciliation, matched-control samples next day and morning samples for the basal level. Every boy filled in a sociometry form, Buss-Durkee Hostility Inventory, Eysenk Personality test and the Revised Children’s form for the Manifest Anxiety Scale. The stress-reduction role of peacemaking was supported on the physiological level. The level of stress-related hormones was higher when no reunion occurred.

Introduction

Natural conflict management mechanisms in nonhuman and human primates have received the attention they deserve only recently, although they are central to the functioning of every social system (Aureli et al., 2002; Aureli and de Waal, 2000; Aureli and Schaafner, 2002; Aureli and Schino, 2004; Butovskaya, 1999, 2003; Butovskaya and Kozintsev, 1999; de Waal, 1993, 2000). Peacemaking perspectives in social animals and humans provide a complementary approach to the ways the social systems function and the ways that social relationships are regulated on a natural basis (de Waal, 2000; Aureli et al., 2002). Reunion is an important instrument for restoring damaged social bonds between group members and serves as a stress reduction mechanism for gregarious nonhuman primates and humans (Aureli and Smucny, 2000).

Humans are equipped with evolutionary-based physiological mechanisms of coping with social stress, and among others, dehydroepiandrosterone sulfate (DHEA-S) hormone plays a role in stress response and may have some protective function under stressful conditions (Morgan et al., 2004). The DHEA-S level is increased by stress in healthy humans, and the DHEA-S/cortisol ratio may indicate a buffering anti-stress effect.

As demonstrated by previous studies, two main factors drive the process of reconciliation in children: an emotional one rooted in fear of damaging valuable social bonds, and a rational one based on cultural norms and recognition of ingroup membership (Butovskaya and Kozintsev, 1999; Butovskaya, 2001a, b). Due to complex interactions between these motives, the probability of reconciliation is not in linear correlation with degree of friendship within a dyad.

The aim of this study was to find a hormonal basis of conflict resolution and to confirm the stress reduction hypothesis on a physiological level. We were also interested in finding status and relationship quality differences in physiological reactions to conflict with peers followed with reunion and without reunion.

Methods

We conducted direct ethological observations of aggressive and post-aggressive interactions between boys aged between 7 and 11 years. The boys (n=30) were observed during free play in one of the Russian summer camps. Observational procedures were based on those developed for studies of reconciliation in nonhuman primates (de Waal and Yoshihara, 1983) and verified later for studies on children (Butovskaya et al., 2000; Butovskaya and Kozintsev, 1999). The data were collected for each group member when he was a victim in conflicts of two types: with reunion 10 minutes after conflict termination and 10 minutes after conflict without reunion (post-conflict—PC). In both cases saliva samples were taken 10 minutes after conflict termination and immediately frozen at...
−20°C. At the same time next day former opponents were again observed during a 10-minute period, and then saliva was taken from the former victim (matched control—MC). To learn the basic levels of cortisol and DHEA-S saliva was taken also in the morning immediately after awakening (four samples per each boy). Then all the samples were processed in the laboratory by the immune-fermentative method (IFM) using the standard cortisol (saliva) and DHEA-S (saliva) Elisa diagnostic kits developed by DRG International Inc. (USA). All assays were done according to kit protocol, and the controls fell within the accepted limits. Inter-assay and intra-assay coefficients of variation were less than 10%. We selected these hormones for this study because cortisol is one of the most reliable glucocorticoids used as a stress indicator in animals and humans, particularly in children (Akyuz et al., 1996; Aono et al., 1997; Thornhage, 2002) and DHEA-S functions as an anti-stress hormone protecting against the destructive effects of cortisol in humans (Kaminska et al., 2000; Young et al., 2002).

The following behavioural categories were registered for each focal child during observations: symmetry of aggressive interactions (occurrence of counterattacks from victim); contact or noncontact aggression; contact or noncontact affiliative behaviour; dominant or subordinate behaviour, initiation of spatial proximity (Butovskaya, 2001b); interventions of third parties into a conflict with the intention of stimulating a friendly reunion (Butovskaya and Kozintsev, 1999).

All boys were also asked to enumerate three group members whom they would like to invite to a birthday party as well as three other boys whom they would never invite. These data were used for the construction of a sociometric matrix on popularity. We also used these data to estimate the quality of relations in each interactive pair: close friends—those who invite each other to the birthday party, and antagonists—those who in no case invite each other; all the other pairs were regarded as acquaintances.

All boys engaged in this study filled in the Buss-Durkee Hostility Inventory (Buss and Durkee, 1957), the Eysenck Personality Inventory (Eysenck and Eysenck, 1964) and the Revised Children’s for of Manifest Anxiety Scale (Reynolds and Richmond, 1978).

The data were subjected to statistical analysis using an SPSS-10 Software packet. We used the Wilcoxon signed ranks test for paired samples to compare levels of cortisol and DHEA-S in PC-MC pairs and for PC pairs with and without reunion, and ANOVA for testing the influence of different types of aggression on hormonal level; Spearman correlations and partial correlations were also used for data analysis.

**Results**

The difference between cortisol levels in PC with and without reunion was significant, Z = −3.41, p = 0.001, n = 22. The difference in the level of cortisol in PC with reunion and MC period next day was not significant, Z = −0.36, NS, n = 23 (Fig. 1). But if no reunion happened the cortisol level in PC was significantly higher than in MC, Z = −2.96, p = 0.003, n = 21 (Fig. 2).

A Wilcoxon signed ranks test for the DHEA-S PC level for cases with and without reunion revealed significant differences, Z = −2.12, p = 0.003, n = 25. The DHEA-S level in PC with reunion was comparable to the MC level, Z = −0.435, NS, n = 24 (Fig. 3). Although the DHEA-S level in PC without reunion was higher than in MC without reunion, this difference was not significant according to the Wilcoxon signed ranks test (Fig. 4).

The level of DHEA-S rose exponentially with increase of intensity of aggression (Fig. 5).

In cases with the higher level of cortisol and DHEA-S in PC, the more intensive affiliative patterns were used for bond-restoring purposes: r = .514, p < .01, n = 25 and r = .459,
We examined the differences in the level of cortisol and DHEA-S in pairs of close friends, acquaintances and antagonists for post-conflicts with reunion and post-conflicts without reunion. For PC with reunion it was found that the highest level of DHEA-S was typical for close friends (3.53 ± 2.04) and lowest for antagonists (1.80 ± .99); unfortunately these data were not significant because of the relatively small sample of close friends and antagonists. The levels of cortisol in different types of pairs were more similar (1.30 ± 1.30 for close friends, 1.80 ± .14 for antagonists). For PC without reunion only two types of pairs were registered: the acquaintances and the antagonists. The level of cortisol was higher for acquaintances (2.09 ± 1.68) than for antagonists (2.24 ± .92), t=2.339, df=18, p=.04. The same was true for the level of DHEA-S (5.98 ± 5.89 for acquaintances, 3.97 ± 4.87 for antagonists, t=2.046, df=20, p=.05).

$p<.05$, n=26 accordingly.

We calculated the DHEA-S/cortisol ratio for morning samples (mean), post-conflicts with peacemaking and without peacemaking. In all three cases this ratio was minimal for the medium rank cohort on popularity (Fig. 6).

The morning saliva cortisol level positively correlated with irritability, measured by the Buss-Durkee Hostility Inventory: $r_c=0.676$, $p<0.001$, n=20. DHEA-S after conflict without reunion positively correlated with extraversion measured by the Eysenck Personality Inventory: $r_c=0.583$, $p<0.05$, n=16.

The DHEA-S/cortisol ratio in post-conflicts without reconciliation was regressed on anxiety measured with RCMA (ANOVA $F_{(1,12)}=8.619$, $R^2=.42$, $\beta=-.841$, $p=.12$). This was true for the whole sample regardless of social status (Partial correlation $r=-.567$, $p=.043$, n=11, controlling for...
social status).

Discussion

It was demonstrated by E. Mikics with co-authors that the high level of glucocorticoids rapidly produced by activation of the hypothalamus may in turn produce a new activation of the very same aggressive brain mechanism, forming positive feedback (Mikics et al., 2004). We suggest that post-conflict reunion functions as a powerful behavioural mechanism breaking this circle. Reconciliation decreases the probability of new attacks and minimizes the harmful consequences of social conflict for the group members.

Our study provides more data confirming the idea that DHEA-S functions as an antiglucocorticoid hormone (Kaminska et al., 2000; Young et al., 2002).

The mediating role of emotion is evident in post-conflict situations. Anxiety caused by aggressive conflict functions as an intervening variable facilitating reconciliation and reducing the risk of new attacks by a former aggressor (Aureli and Schaik, 1991; Kutsukake and Castles, 2001). Due to reconciliation, the former social bonds between opponents are restored and anxiety is reduced to the initial level (Aureli and Smucny, 2000).

Our data on children and adolescents obviously confirm the stress-reduction hypothesis (Aureli, 1997; Aureli and Smucny, 2000) on the hormonal level. The more time passed between the end of aggression and post-conflict reunion, the higher was the level of cortisol 10 minutes after conflict termination. The damage to social bonds between group members caused by aggression leads to serious emotional discomfort in former opponents as reported by ethological data and personal interviews with children (Butovskaya, 2001a, b). Here we provide the first hormonal evidence of the high level of competence in reading an opponent’s emotions in boys of 7–11 years of age. The higher the post-conflict level of victims’ cortisol, the more effective were the means of affiliation applied for reunion and anxiety reduction.

DHEA-S counteracted the detrimental effects of high cortisol production. DHEA-S secretion was the highest in cases of severe physical aggression and seemed to provoke more intensive affiliative reactions in former opponents.

The positive correlation between the post-conflict DHEA-S level without reunion and personal scores on extraversion may also be interpreted in support of the stress reduction hypothesis. Extraverts do experience higher physiological stress after aggression.

Some authors suggested that the DHEA-S/cortisol ratio may be the best indicator of successful coping with stressful events (Morgan et al., 2004). The mean DHEA-S/cortisol ratio was minimal in the boys ranking medium in popularity, suggesting that they were less successful in coping with stress caused by threat and aggression.

Our survey also provides certain physiological support for the valuable relation hypothesis of post-conflict reunion (Cords and Aureli, 2000; Butovskaya et al., 2000). The level of cortisol in boys after a conflict with friends was not significantly higher compared to antagonists. Meantime, the level of DHEA-S was evidently higher in friends compared to antagonists. This means that the anti-stress buffering DHEA-S reaction is much stronger when close friends were in conflict with each other, rather than antagonists.

Mediation is obviously an important strategy for controlling the in-group social equilibrium, but as we have found for this particular group of boys, the level of cortisol 10 minutes after a conflict with a third-party peacemaker was significantly higher than in situations with reunion without mediation. These data may be interpreted in two different ways: 1. the higher level of cortisol was due to the fact that in these cases former opponents had more problems with reunion (focal victims were stressed more than in other cases) and intrusion by mediators was necessary for conflict resolution; 2. if mediators intrude, the whole process of reunion is less complete in form, or reunion initiation under the pressure of thirdparties is less effective for stress reduction. It was found earlier in a number of studies that a teacher’s mediation does not always produce the desired bond-restoring effect: if former opponents are forced to reconcile by the teacher, they are less inclined to associate after conflict than peers who reconciled independently (Butovskaya and Kozintsev, 1999; Verbeek et al., 2000).

This paper covers data collected on victims and presents the first stage of the project; for the next step we are going to report on the hormonal basis of post-conflict behavior in aggressors as well; the relationship quality will also be a focus of future analysis. The age and gender factors influencing post-conflict emotions also need to be examined.

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