



## Sex hormones and biogenic amine turnover of sex offenders in relation to their temperament and character dimensions

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### Abstract

Relationships between Cloninger's temperament and character dimensions and plasma sex hormone levels and biogenic amine turnover were studied in male prison inmates convicted of rape ( $n=61$ ) or child molestation ( $n=24$ ) and normal male controls ( $n=25$ ). The participants completed the Temperament and Character Inventory (TCI), which includes the temperament dimensions Novelty Seeking, Harm Avoidance, Reward Dependence and Persistence as well as the character dimensions Self-Directedness, Cooperativeness and Self-Transcendence. Plasma levels of testosterone, dihydrotestosterone, sex hormone binding globulin, luteinizing hormone (LH) and follicle-stimulating hormone were estimated in plasma samples and 5-hydroxyindoleacetic acid (5-HIAA), homovanillic acid (HVA), and 3-methoxy-4-hydroxyphenylglycol (MHPG) in urine samples. Both sex-offender groups had higher Novelty, Seeking and lower Reward Dependence, Self-Directedness and Cooperativeness scores compared with the controls. Plasma levels of testosterone and dihydrotestosterone were significantly higher in rapists than in controls. Novelty Seeking scores were positively correlated with LH levels in rapists, and with testosterone levels in child molesters. Harm Avoidance scores were negatively correlated with 5-HIAA levels in rapists and with HVA levels in child molesters. In rapists, the calculated free androgen index showed a negative correlation with 5-HIAA. For the sex offender sample as a whole, the subgroup with high testosterone levels had higher Harm Avoidance scores, the subgroup with low HVA levels had lower Cooperativeness scores, and the subgroups with high 5-HIAA or MHPG levels had lower Persistence scores. The results indicate that Novelty Seeking behavior in the group of rapists is associated with a hyperactive hypothalamic-pituitary-gonadal axis. In addition, low serotonin turnover and low dopamine turnover seem to be associated with a passive-avoidant behavioral style in rapists and child molesters, respectively.

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### 1. Introduction

The behavioral profile of sexual offenders is an important area for study as different aspects of an

individual's behavior may affect treatment outcome. Sex offenders have been found to be more sexually isolated, more assaultive, and more resentful than the general population of offenders (Valliant and Bergeron, 1997). Rapists, in comparison with child molesters, tend to be more assertive, are less likely to suffer from mental retardation or an organic brain

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syndrome, and are half as likely to have been sexually abused (Bard et al., 1987). The focus in recent models of sexual aggression has been on antisocial personality traits with little attention to other personality traits or dimensions. However, psychometric studies have found a diversity of maladaptive personality traits in rapists (Berner et al., 1992). Cloninger et al. (1993), in their temperament and character theory, attempted to show the interrelationships of hereditary and environmental factors. Based on this model, Ruchkin et al. (1998) found higher levels of Novelty Seeking, Harm Avoidance and Self Transcendence, as well as lower levels of Self-Directedness, in male delinquent adolescents. Furthermore, studies investigating temperament traits and their biological correlates have found that levels of Novelty Seeking, Harm Avoidance and Reward Dependence appeared to be associated, respectively, with dopaminergic, serotonergic and noradrenergic systems (Zuckerman, 1996; Ruegg et al., 1997; Cloninger, 1998).

In addition, neuroendocrine parameters, especially androgens, seem to play a critical role in human sexuality, aggressive behavior and sexually aggressive behavior (Christiansen and Knusmann, 1987; Christiansen, 1998). Testosterone levels of violent offenders were found to be associated with increased aggressiveness, sensation seeking, suspiciousness and reduced socialization (Virkkunen et al., 1994; Rubinow and Schmidt, 1996; Rasanen et al., 1999), and abnormally high androgen levels have been found in men with different types of sexual aggression (Rada et al., 1976; Langevin et al., 1985), although some researchers failed to replicate these findings (Rada et al., 1983; Bradford and McLean, 1984). Several serotonergic disturbances (Maes et al., 2001a) and increased epinephrine levels (Maes et al., 2001b) have been found in pedophiles, while the hormone-neurotransmitter interaction has showed to possibly control sexuality and especially deviant sexual behavior (Everitt and Bancroft, 1991; Hull et al., 1999; Kafka, 1997).

In a previous study in rapists, we found that their plasma levels of testosterone and dihydrotestosterone, as well as the calculated free androgen index, were significantly higher, while levels of 5-hydroxyindoleacetic acid, the major metabolite of serotonin, were significantly lower than in controls

(Giotakos et al., 2003). The aim of the present study was to search for possible relationships between temperament-character dimensions, as they are described by Cloninger et al. (1993), and levels of plasma androgen and urine monoamine metabolites, in males who have been convicted of rape or child molesting, in comparison with healthy controls.

## 2. Methods

### 2.1. Subjects

Sex offenders (rapists,  $n=61$ ; child molesters,  $n=24$ ) consented to participate in this study after the procedure had been fully explained. Eight rapists and seven child molesters declined to participate either because they had difficulties with the questionnaire administered or they refused to have their blood drawn. Twenty-five drug-free men, without a history of mental or physical disorder, who were recruited from the staff of the local hospital, were used as a control group. Their ages ranged from 20 to 43 years (mean=29.3, S.D.=6.6). All sex offenders were prison inmates at the only institution in Greece specialized for sexual offenders. Table 1 presents their basic demographic, criminological, and psychological data. Fifteen rapists and one child molester had not received a primary school education for social or cultural reasons. Eight rapists and two child molesters had borderline intelligence scores (IQ ranged from 70 to 90) according to the medical records, while none was mentally retarded. All subjects had undergone drug detoxification and alcohol withdrawal during their term of incarceration. Five rapists and five child molesters were receiving medication during the evaluation period. Two of them received phenytoin (1000 mg/day) and carbamazepine (800 mg/day), respectively, because they suffered from epilepsy. Among treatments administered for other disorders, one offender received paroxetine (20 mg/day) for panic disorder, one risperidone (3 mg/day) for psychosis, two diazepam (10 mg/day) for anxiety disorder, and four perphenazine (4 mg/day) for personality disturbances. Two individuals suffered from cirrhosis, but their biochemical examinations were in the upper normal range.

Table 1  
Basic demographic, criminological, and psychological data, of the rapists and the child molesters

	Rapists N=61 Mean ± S.D.	Child molesters N=24 Mean ± S.D.
Age	30.9 ± 8.8 (range:21–58)	42.0 ± 10.4 (range:21–55)
Sentence (years)	11.6 ± 9.5	17.2 ± 12.8
Stay in the prison (months)	22.2 ± 20.7	35.2 ± 28.2
Age of victims	29.5 ± 15.4	10.4 ± 3.0
	N (%)	N (%)
Illiterate	15 (25%)	1 (4%)
Primary + high school (9 years)	25 (27%)	(62%)
Low or bad financial	60 (97%)	21 (86%)
Single	31 (53%)	5 (24%)
Divorced	10 (17%)	8 (34%)
Violence between the parents	30 (51%)	7 (30%)
Parent in the prison	6 (10%)	1 (5%)
Murder not related to sexual violence	5 (12%)	0 (0%)
Murder related to sexual violence	2 (3%)	0 (0%)
Past drug use (including alcohol)	35 (58%)	11 (51%)
Suicidal behavior (including self-mutilation)	10 (17%)	5 (20%)
Admission in psychiatric clinic	7 (15%)	4 (16%)
Past psychiatric drug treatment	15 (25%)	9 (37%)
Present psychiatric drug treatment	5 (12%)	5 (20%)
Borderline intelligence	8 (14%)	2 (8%)
History of childhood sexual abuse	6 (10%)	5 (22%)
Bisexual	16 (27%)	10 (43%)
Homosexual	0 (0%)	2 (8%)

## 2.2. Psychological measures

Among the sex offenders, 52 rapists and 24 child molesters were able, because of their educational level, to complete the Temperament and Character Inventory (TCI; Cloninger et al., 1994). The TCI was administered to all subjects by the same examiner (O.G.). The TCI is a self-report inventory based on a seven-factor psychological model of the structure and development of personality. In the present study we used the version of the TCI that consists of 140 questions and a five-grade answer scale. Temperament dimensions include the heritable Novelty Seeking (NS), which measures exploratory activity in response to novelty, impulsive behavior, and active avoidance of frustration; Harm Avoidance (HA), which measures pessimistic worry in anticipation of future problems; Reward Dependence (RD), which measures behaviors that depend on approval of others; and Persistence (PE), which is represented by perseverance in spite of frustration and fatigue. The three Character dimen-

sions aim to show how people identify themselves in the following ways: as autonomous individuals, Self-Directedness (SD); as internal parts of humanity, Cooperativeness (CO); and as integral parts of the universe, Self-Transcendence (ST).

## 2.3. Biological measures

A total of 59 rapists and 19 child molesters consented to have a single blood sample drawn. After blood collection between 08.00 and 10.00 h, the blood samples were centrifuged immediately, and 3 ml of serum from each participant were frozen at  $-30^{\circ}\text{C}$  until determination. Commercially available radioimmunoassay kits (BioChem ImmunoSystems and Dia-Sorin) were used for the determination of testosterone, dihydrotestosterone (DHT), sex hormone binding globulin (SHBG), luteinizing hormone (LH), and follicle-stimulating hormone (FSH). Morning urine samples were also collected from 61 rapists and 22 child molesters. Urine was frozen at  $-30^{\circ}\text{C}$  until

determination. The concentrations of 5-hydroxyindoleacetic acid (5-HIAA) and homovanillic acid (HVA) were estimated by high performance liquid chromatography (HPLC) with electrochemical detection. A total of 20  $\mu$ l of 1:20 diluted urine with and without standards were directly injected into the system. Total 3-methoxy-4-hydroxyphenylglycol (MHPG) was estimated by gas chromatography with electron capture detection after an overnight hydrolysis with glucuronidase, extraction into ethyl acetate, and derivatization with trifluoroacetic anhydride. Creatinine was estimated in the urine samples, and the concentrations of the metabolites were expressed in nmol/mg creatinine. The inter- and intra-assay coefficients of variation were approximately 5% for all estimations. Although the exact significance of urinary levels of 5-HIAA, HVA, and MHPG, and their origin, are regarded as questionable, previous studies have shown that the central and peripheral noradrenaline systems are functionally related, while approximately 25% of HVA derives from the brain (Maas et al., 1979). In addition, although urinary 5-HIAA expresses to a great extent peripheral serotonin metabolism, other peripheral measures of serotonin activity may be relevant, e.g. platelet serotonin and whole body tryptophan, which have been studied as predictors of suicidal behavior in psychiatric inpatients (Pfeffer et al., 1998).

#### 2.4. Statistical procedures

For the statistical analysis, means and standard deviations were calculated describing the variables under investigation. Temperament and character dimensions, as well as biochemical data of rapists and child molesters, were compared to data of the

controls by multivariate analysis of covariance (MANCOVA), with age and body mass index as a covariate, followed by post hoc comparisons. The non-parametric Spearman's correlation test was used to examine relationships between the personality dimension scores and the biochemical data. To investigate further temperament and character dimensions in relation to levels of testosterone and urinary biogenic metabolites, we divided the total group of sex offenders into two subgroups, with low or high levels of each variable, with a cutoff point at the 95% confidence interval determined in the group of controls. After that, the dimension scores were compared using non-parametric Kruskal–Wallis analysis of variance (ANOVA).

### 3. Results

The dimensions Novelty Seeking and Self-Transcendence were found significantly increased, while the dimensions Reward Dependence, Self-Directedness, and Cooperativeness were found significantly decreased in both sex offender groups in relation to the control group. The dimension Harm Avoidance in both sex offender groups and Persistence in the child molesters group did not show any significant difference, while Persistence scores in rapists were significantly higher than in controls (Table 2, Fig. 1). Plasma testosterone and dihydrotestosterone levels were significantly increased in the group of rapists compared with controls (Table 3). The 5-HIAA concentrations showed a marginally significant decrease in the group of child molesters compared with concentrations in the controls (Table 4).

Table 2

Means, S.D. and *P* values, of the temperament and character dimensions in controls, rapists, and child molesters. Statistical analysis by MANOVA: Wilk's lambda=0.395, d.f.=14,184, *P*<0.0001

Group	<i>N</i>	Age	Novelty seeking	Harm avoidance	Reward dependence	Persistence	Self-directedness	Cooperativeness	Self-transcendence
Controls	25	29.3 ± 6.6	53.5 ± 9.9	53.0 ± 8.2	65.9 ± 8.3	71.4 ± 9.0	78.1 ± 13.4	75.2 ± 11.3	40.6 ± 10.6
Rapists	52	31.8 ± 9.6	69.1 ± 11.8	53.8 ± 10.0	57.0 ± 8.6	61.7 ± 11.2	59.7 ± 9.9	52.2 ± 11.3	55.1 ± 9.7
Child molesters	24	42.0 ± 10.1	62.5 ± 12.1	52.1 ± 8.9	56.9 ± 11.9	66.6 ± 14.5	62.1 ± 11.4	57.1 ± 15.7	58.9 ± 9.3
Post-hoc comparisons (Tukey test for unequal <i>n</i> )									
Controls vs. rapists			0.0001	0.95	0.004	0.01	0.0001	0.0001	0.0001
Controls vs. child molesters			0.02	0.94	0.004	0.33	0.0001	0.0001	0.0001
Rapists vs. child molesters			0.12	0.81	0.99	0.32	0.74	0.38	0.38

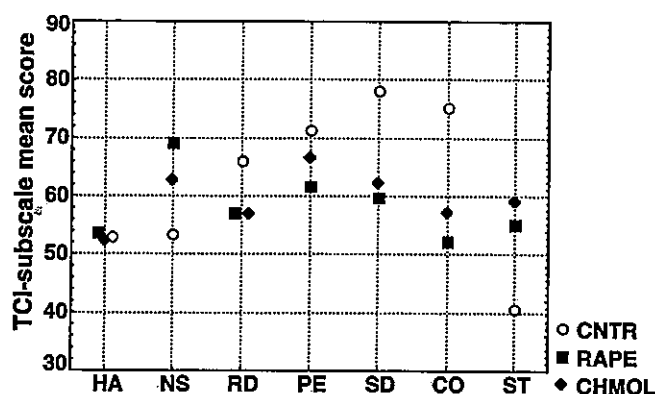


Fig. 1. Mean values of the temperament dimensions Harm Avoidance (HA), Novelty Seeking (NS), Reward Dependence (RD), and Persistence, and the character dimensions Self-Directedness (SD), Cooperativeness (CO), and Self-Transcendence (ST) in controls and subjects with convictions for rape and child molestation.

Spearman's  $R$  correlation between the personality dimensions and the hormonal levels showed the following results: In the controls, LH levels were positively correlated with Cooperativeness ( $R=0.40$ ,  $P=0.05$ ). In the group of rapists, LH levels were positively correlated with the Novelty Seeking score ( $R=0.28$ ,  $P=0.05$ ). In rapists also, the calculated free androgen index (FAI) showed a negative correlation with 5-HIAA ( $R=-0.35$ ,  $P=0.02$ ). In the group of child molesters, testosterone levels were positively correlated with Novelty Seeking scores ( $R=0.49$ ,  $P=0.03$ ) and negatively correlated with Persistence scores ( $R=-0.46$ ,  $P=0.05$ ).

The correlations between the personality dimensions and the monoamine metabolite concentrations

showed the following results: HVA levels were negatively correlated with Harm Avoidance scores ( $R=-0.63$ ,  $P=0.001$ ) in child molesters, and positively correlated with Cooperativeness ( $R=0.38$ ,  $P=0.05$ ) in rapists, while in the latter 5-HIAA levels showed a negative correlation with Harm Avoidance scores ( $R=-0.34$ ,  $P=0.02$ ).

We divided the whole sex offender sample into two subgroups, with low and high levels of each biological variable, using as cutoff points the following 95% confidence limits of the control group: for testosterone 5.78 mg/ml, for 5-HIAA 15.39 nmol/mg, for HVA 10.44 nmol/mg, and for MHPG 5.28 nmol/mg. The comparison of dimension scores between the created subgroups, based on non-parametric Kruskal–Wallis ANOVA, revealed the following: The high testosterone subgroup had a significantly higher Harm Avoidance score ( $P=0.04$ ) than the low testosterone subgroup. The high HVA subgroup had higher Cooperativeness ( $P=0.01$ ) and Self-Transcendence scores ( $P=0.03$ ) than the low HVA subgroup. Both the high MHPG and high 5-HIAA subgroups had lower Persistence scores ( $P=0.04$  and  $P=0.001$ , respectively) in comparison with the low MHPG and low 5-HIAA subgroups, respectively.

#### 4. Discussion

Compared with controls, both rapists and child molesters had higher Novelty Seeking and Self-Transcendence scores on the TCI and lower Reward Dependence, Self-Directedness, and Cooperativeness

Table 3

Means, S.D. and  $P$  values of the plasma hormone levels in controls, rapists, and child molesters. Statistical analysis by MANCOVA, covariates Age and Body mass index. Wilk's lambda=0.749, d.f.=12,186,  $P=0.006$

Group	$N$	Age	Testosterone, ng/ml	Dihydrotestosterone, pg/ml	Sex hormone binding globulin (SHBG), nmol/l	Free androgen index	Luteinizing-hormone (LH), mIU/ml	Follicle-stimulating hormone (FSH) (mIU/ml)
Controls	25	29.3 ± 6.6	6.72 ± 2.29	385 ± 194	84.6 ± 44.4	31.2 ± 12.2	2.79 ± 1.08	2.37 ± 1.25
Rapists	59	29.7 ± 8.5	8.73 ± 3.09	555 ± 215	90.1 ± 34.9	37.1 ± 15.9	3.40 ± 1.49	3.11 ± 2.04
Child molesters	19	42.0 ± 10.1	7.65 ± 3.67	476 ± 236	91.0 ± 40.7	33.5 ± 21.5	3.43 ± 2.02	3.58 ± 1.71
Post hoc comparisons (Tukey-test for unequal $n$ )								
Controls vs. rapists			0.04	0.02	0.86	0.32	0.29	0.24
Controls vs. child molesters			0.59	0.39	0.86	0.87	0.36	0.054
Rapists vs. child molesters			0.48	0.53	0.99	0.72	0.99	0.63

Table 4

Means, S.D. and *P* values of the urinary biogenic amine metabolites (nmol/mg creatinine) in controls, rapists, and child molesters. Statistical analysis by MANCOVA, covariates Age and Body mass index. Wilk's lambda=0.910, d.f.=6198, *P*=0.15

Group	<i>N</i>	Age	Body mass index (BMI)	5-Hydroxyindoleacetic acid (5-HIAA)	Homovanillic acid (HVA)	3-Methoxy-4-hydroxy-phenylglycol (MHPG)
Controls	25	29.3 ± 6.6	25.4 ± 2.8	17.9 ± 6.0	13.0 ± 5.9	6.4 ± 2.7
Rapists	61	30.9 ± 8.8	25.6 ± 2.7	15.7 ± 3.8	12.9 ± 5.1	5.8 ± 3.1
Child molesters	22	42.0 ± 10.4	25.1 ± 2.9	14.8 ± 5.3	13.7 ± 5.8	5.8 ± 2.8
Post-hoc comparisons (Tukey test for unequal <i>n</i> )						
Controls vs. rapists				0.26	0.99	0.75
Controls vs. child molesters				0.07	0.89	0.69
Rapists vs. child molesters				0.77	0.88	0.99

scores, while Persistence scores were lower only in rapists. On the basis of Cloninger's theory, we can suggest that both rapists and child molesters have a common temperament profile characterized by impulsivity, active avoidance of frustration, quick loss of temper, lack of personal intimacies, and insensitivity to social cues and pressures. Rapists, in addition, seem to be more distant and to quit more easily before maximal effort has been expended. Furthermore, both sex offender groups were found to be characterized by a common character profile dominated by behaviors not directed by personal goals or values, by difficulty in accepting others and, consequently, by lack of empathy. These findings are in agreement with previous findings in delinquent adolescents who had high scores on Novelty Seeking, Harm Avoidance, and Self-Transcendence, and low scores on Self-Directedness (Ruchkin et al., 1998). Low Self-Directedness and Cooperativeness scores have been found to be common characteristics of all categories of personality disorders (Cloninger et al., 1993).

Recent studies found higher concentrations of testosterone in cerebrospinal fluid in alcoholic perpetrators of domestic violence (George et al., 2001), and higher total serum testosterone concentrations in subjects with type II alcoholism and antisocial personality disorder in a forensic psychiatric population compared with values in healthy subjects (Steinheim et al., 1998). Earlier studies have shown high androgen levels in men convicted for rape or other types of sexual aggression (Rada et al., 1976; Langevin et al., 1985), while a recent study showed that saliva testosterone was positively correlated with antisocial personality characteristics in two small groups of

imprisoned rapists and child molesters (Aromaki et al., 2002). There is agreement between these suggestions and our findings showing increased levels of testosterone and dihydrotestosterone in the subgroup of rapists. An earlier research report on a subsample from the present group of rapists had similar findings enhanced by a significantly higher free androgen index and significantly lower levels of urine 5HIAA concentrations in comparison with controls (Giotakos et al., 2003). Impulsivity and sensation seeking characterize both the Novelty Seeking dimension and sex offender behavior, while androgens have been linked to impulsive/aggressive behavior (Cloninger, 1993; Christiansen, 1998). Recent findings have shown that testosterone baseline plasma levels in healthy subjects are positively correlated to Novelty Seeking scores, measured with the Tridimensional Personality Questionnaire (Gerra et al., 1999). The present findings provide further support for association between the Novelty Seeking dimension and androgen levels, as the Novelty Seeking dimension was found to be positively correlated with testosterone in child molesters ( $R=0.49$ ,  $P=0.03$ ) and with LH in rapists ( $R=0.28$ ,  $P=0.05$ ). However, the subgroup of sex offenders with high testosterone levels did not have higher Novelty Seeking scores but instead had significantly higher Harm Avoidance scores as compared with the low testosterone subgroup. According to Cloninger (1987), the combination of high Novelty Seeking, low Harm Avoidance and low Reward Dependence is a typical characteristic in antisocial personality, while the combination of high Novelty Seeking, high Harm Avoidance and low Reward Dependence characterizes explosive personalities.

For a number of the sex offenders in the current sample, androgen levels seem to be linked to a behavior pertaining to the above-mentioned personality spectrum, which is characterized by impulsivity (high Novelty Seeking) and frequent unfriendly feelings (high Harm Avoidance).

Maes et al. (2001a) reported several indicators of serotonergic disturbances in pedophiles, while Gerra et al. (2000) found a relationship between blunting of serotonergic response to *d*-fenfluramine stimulation in healthy subjects and Harm Avoidance scores. These findings support Cloninger's theory concerning the biological mechanism of behavioral inhibition. Harm Avoidance scores in both sex offender groups in the present study did not differ significantly from scores in the control group. However, the negative correlation of Harm Avoidance scores with levels of the serotonin metabolite 5-HIAA ( $R = -0.34$ ,  $P = 0.02$ ) in the subgroup of rapists supports an association between low serotonin turnover and passive avoidant behavior in these subjects. Although the present findings should be interpreted with caution, they can be discussed in parallel with previous findings of a relationship between Harm Avoidance scores and Hamilton Depression Rating Scale scores (Ampollini et al., 1997), and a relationship between Harm Avoidance and the serotonin release from presynaptic neurons and, consequently, postsynaptic serotonin receptor down-regulation (Gerra et al., 2000). In addition, the serotonin transporter gene has been linked to Harm Avoidance (Ruegg et al., 1997), while a linkage has been suggested between a functional polymorphism in the promoter of the human serotonin transporter gene and two anxiety-related subdimensions of Harm Avoidance (Mazzanti et al., 1998), as well as Harm Avoidance in an elderly population (Ricketts et al., 1998). In addition to the negative correlation between Harm Avoidance scores and 5-HIAA levels in the rapists, we found a negative correlation of Harm Avoidance scores with the dopamine metabolite HVA in the child molesters ( $R = -0.63$ ,  $P = 0.001$ ), which suggests that low dopamine turnover in child molesters is associated with their passive-avoidant behavior. This association between Harm Avoidance and low serotonin turnover, as well as low dopamine turnover in these sex offender subgroups, can also be seen in relation to the findings of recent studies of high comorbidity with mood

disorders in pedophiles (Raymond et al., 1999) and of the effectiveness of serotonergic drugs in sexually aggressive individuals (Kafka, 1997).

It has been suggested that mesolimbic and mesofrontal dopaminergic projections may be involved in the development of Novelty Seeking, and that novelty-seekers have high dopamine and low serotonin function (Zuckerman, 1996). However, so far Novelty Seeking has been found to be associated both with dopamine hypoactivity (Ruegg et al., 1997) and with dopamine hyperactivity (Netter et al., 1996). We failed to find either a correlation between Novelty Seeking and dopamine turnover in the sex offender subgroups or higher Novelty Seeking score in the high HVA sex offender subgroup. Regarding dopamine turnover, we found that the low HVA subgroup had a lower Cooperativeness score compared with the high HVA subgroup. Knowing that individuals with low Cooperativeness have difficulty in accepting others and demonstrate hostility (Cloninger et al., 1993), and having also in mind the above-mentioned association between low dopamine turnover and avoidant behavior in child molesters, we can suggest that low dopamine turnover in this sex offender sample is associated with their passive-aggressive behavior.

Furthermore, we found that the sex offender subgroup with high MHPG levels had lower Persistence scores relative to scores in the low MHPG subgroup, which suggests that sex offenders with high MHPG turnover are more distant and isolated. This finding is in accordance with recent findings (Maes et al., 2001b) that plasma concentrations of catecholamines, especially epinephrine, are significantly increased in pedophiles. The present finding further support previous suggestions that norepinephrine modulates aggressiveness through its stimulatory effect on testosterone secretion, influencing basal testosterone levels (Gerra et al., 1997). In view of the fact that the Persistence dimension was originally thought to be a component of Reward Dependence (Cloninger et al., 1993), the present finding is consistent with previous findings that norepinephrine plays a modulatory role in the reward system (Cloninger et al., 1993). In addition, low MHPG levels have been observed in subjects with high Reward Dependence (Ruegg et al., 1997), while a hypersensitivity of alpha-2-adrenoceptors, deriving from decreased norepinephrine secre-

tion, has been found in individuals with low Reward Dependence scores (Cloninger, 1998). Finally, we found that the sex offender subgroup with high 5HIAA levels was more distant and isolated (low Persistence) compared with the subgroup with low 5HIAA levels. This indicates an association between high serotonin turnover and the isolated behavior of these individuals, a finding that at present is difficult to interpret. However, the negative correlation between 5-HIAA and the free androgen index in the subgroup of rapists may indicate a hormone-neurotransmitter interaction that has previously been suggested to be involved in sexuality and especially in deviant sexual behavior (Everitt and Bancroft, 1991; Kafka, 1997; Hull et al., 1999).

In summary, regarding the sample of sex offenders as a whole, indicators of hostility seem to be associated with low dopamine turnover, while indicators of isolation seem to be associated with low norepinephrine turnover. Especially in the group of rapists, we can suggest that Novelty Seeking behavior in these individuals is associated with a hyperactive hypothalamic-pituitary-gonadal axis, while their avoidant behavior seems to be associated with low serotonin turnover. Finally, in child molesters, avoidant behavior seems to be associated with low dopamine turnover. These findings should be interpreted with caution and await confirmation in larger samples.

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