

## CATECHOLAMINE EXCRETION IN YOUNG BOYS AND THEIR PARENTS AS RELATED TO BEHAVIOR\*

### *A Preliminary Report*

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Catecholamine excretion during night rest was examined in 50 boys, aged 8 to 9 years, and their parents. The families were sampled from a longitudinal study on growth and mental development, and the catecholamine measures were related to various measures of behavior that had been gathered during the boys' lives as well as to data on the disciplinary procedures employed by the parents. It was shown that (a) the boys' noradrenaline excretion rate was positively correlated with that of their mothers, (b) the boys' adrenaline excretion was positively related to their intellectual level and to some indicators of emotionality, and (c) the fathers' noradrenaline-excretion rate was negatively correlated with the frequency at which they smacked their children as well as with their social status. Other possible relationships between catecholamine-excretion levels of sons, mothers, and fathers and disciplinary procedures are discussed.

### INTRODUCTION

Relationships between catecholamine release and various aspects of behavior have attracted considerable interest in recent psycho-endocrine research. Inspired by Cannon's (1929) work on the 'flight-fight reaction' in emergency states, Funkenstein (1956) advanced the hypothesis

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\*\*A later report, including data from a similar sample of girls, is in preparation for publication in the *Scandinavian Journal of Psychology*. (See Lambert, *et. al.*, 1969.)

that anxious reactions are associated with an increase of adrenaline secretion, whereas aggressive behavior is related to an increase of noradrenaline release. The development of techniques for the separate estimation of adrenaline and noradrenaline in urine (Euler & Lishajko, 1961) has greatly facilitated the study of this and related problems, and Funkenstein's hypothesis has obtained some experimental support (e.g. Elmadjian, Hope & Lamson, 1957; Cohen & Silverman, 1959), while its validity has been questioned by other investigators (Frankenhaeuser & Pátkai, 1965). It is important to note that the discrepant views seem to arise mainly in connection with assessing the significance of noradrenaline release for psychological functioning. With regard to adrenaline, the experimental data are much more consistent, and in the work by Frankenhaeuser and her collaborators a functional relationship has been clearly established between adrenaline release and emotional arousal (Frankenhaeuser, Sterky & Järpe,

1962; Frankenhaeuser, Fröberg & Mellis, 1965; Frankenhaeuser, Fröberg, Hagdahl, Rissler, Björkvall & Wolff, 1967). The data suggest that the rate of adrenaline release is related to the intensity rather than the direction of emotion. Thus, an increase of adrenaline in urine has been found in pleasant as well as in unpleasant emotional states (Levi, 1965). Furthermore, adrenaline excretion has been shown to be positively related to cognitive functioning during stress (O'Hanlon, 1965; Frankenhaeuser, Mellis, Rissler, Björkvall & Pátkai, 1966; Pátkai, Frankenhaeuser, Rissler & Björkvall, 1966; Pátkai & Hagdahl, 1967). In some instances a positive correlation has been found also between noradrenaline excretion and cognitive functions (Frankenhaeuser & Pátkai, 1964; Frankenhaeuser *et al.*, 1966), but the results are equivocal.

In the present investigation the problem of catecholamine release and behavior was studied within the frame of a longitudinal investigation conducted in Sweden by Karlberg and his coworkers as part of a cross-cultural research program on growth and mental development in children (Karlberg, Klackenber, Klackenber-Larsson, Lichtenstein, Stensson & Svennberg, 1967). The main aim of the present study was to examine relationships between the excretion rates of adrenaline and noradrenaline in a group of 8- to 9-year old boys and their parents, and to relate the catecholamine measures to data on the behavior of the children at various stages of their development as well as to environmental factors such as the disciplinary procedures employed by the parents. Thus, the investigation takes into account developmental and genetic aspects of catecholamine secretion and factors of social ecology that have received but little attention in research on catecholamines and behavior. It forms part of a long-term research program of Lambert and his coworkers at Cornell University and represents a direct continuation of a study by Wolf and Lambert (unpublished) on catecholamine excretion in a group of

children in Formosa as related to the disciplinary procedures used by their mothers. The results reported in the present paper are to be considered preliminary and the data will be re-analysed, using slightly different statistical procedures, when a parallel investigation on girls has been completed.

## METHOD

### *Subjects and general design*

Fifty boys, aged 8 to 9 years ( $M = 9.0$ ,  $S.D. = 0.6$ ), and their parents participated in the investigation. They were sampled from a group of families participating in a longitudinal study of growth and mental development in children (Karlberg *et al.*, 1967). The initial sample held 212 children, 122 of whom were boys. All the children were born within a three-year period in a town (Solna) in the suburban area of Stockholm, and the socio-economic class distribution of the total group shows good agreement with that of the population in Stockholm (Karlberg *et al.*, 1967).

The sample of the present study comprised 50 of the 52 boys who still lived in their native town and who belonged to complete families. In the remaining two cases the parents were unwilling to participate. The number of families was 48, as the sample contained one pair of twins and one pair of brothers. Each family was paid 60 Swedish cr. (US \$12) for their participation.

A large amount of data on the boys and their families has been gathered by Karlberg and his coworkers over the 10 years during which the study has been in progress. In the present investigation some of the data concerned with social factors and behavioral and emotional development were selected for the purpose of studying relationships between these variables and excretion rates of catecholamines. Since the study of Karlberg *et al.* did not include catecholamine measures, the first task was to collect samples of urine from the 50 boys and their parents for the determination of excretion rates of adrenaline. To obtain the urine samples under reasonably constant and well-controlled conditions it was decided to use night-rest samples. The catecholamine measures thus obtained were correlated with some of the data that had been collected by Karlberg *et al.* during their longitudinal study, and the present preliminary report describes relations between catecholamine excretion and four different categories of social and behavioral variables: social status, intelligence, emotional behavior, and disciplinary procedures.

The privacy of the families was strictly defended, the personal contact being made through a nurse who has been tied to the project for several years.

*Urinary catecholamines*

Three 500 ml bottles, each containing 5 ml 1-N HCl and labelled with the name of son, mother, and father, respectively, were delivered together with type-written instructions at the family's residence one day and picked up the next morning at about 8.30. Care was taken to collect the samples under conditions providing, as far as possible, base-line values of catecholamine excretion during night rest. Hence, samples were collected only on "ordinary week days," Friday, Saturday, and Sunday nights, as well as holiday periods being excluded from the schedule. Furthermore, no family gave samples during or in the week immediately preceding the mother's menstrual period.

Each member of the family was instructed to empty his bladder at bedtime, to collect urine on voiding in the morning, and to note the points of time on the label of the bottle. Careful instructions were given regarding the conditions which might affect the catecholamine excretion and which had to be avoided, such as physical work, intake of drugs, alcohol, coffee, bananas, etc.

The samples were immediately returned to the laboratory, the pH of the urine was adjusted to about 3 with 1-N HCl, and the samples were stored at -18°C until analyzed by the fluorimetric technique of Euler and Lishajko (1961).

*Social status*

A slightly modified version of the Graffar social score (Graffar, 1956) was used to assess social status when the child was one year old. This score was composed of four variables, for each of which a subscore ranging from 1 to 5 was obtained. The variables were: occupation (of the parent with the higher occupation), level of education (of the parent with the higher education), main source of family income, and quality of housing. The possible range of the total score was 4 to 20, higher scores indicating lower social status. Our sample showed a fairly normal distribution, the scores ranging from 8 to 17 (M = 12.6, S.D. = 2.3).

*Intelligence*

Intelligence quotients, as determined by the Swedish version of the Terman-Merrill intelligence test, were available for the ages 5 and 8 years. The means and standard deviations were at 5 years 102.3 and 18.1, respectively, and at 8 years 102.0 and 16.1 respectively.

*Emotional behavior*

Data describing emotional behavior with regard to seven variables were available. They were based on the mother's answers to a series of interview questions, each question being asked at one or several interviews as indicated below:

- (a) How long will he usually lie awake and quiet?
- (b) How is his state of mind in general sensitive or stable?
- (c) Does he often get angry?
- (d) How often does he actively show affection (spontaneous hugging or kissing)?
- (e) Is he a noisy child or is he quiet on the whole?
- (f) Is he afraid of the dark?
- (g) How often does he have temper tantrums?

6	interviews	between	1	and	18	months
8	"	"	1	"	36	"
6	"	"	6	"	36	"
5	"	"	9	"	36	"
3	"	"	36	"	60	"
1	interview	at	8	years		
3	"	"	"	"	"	"

Answers to questions (a-e) were scored by calculating the percentage of interviews at which the mother had given answers belonging to certain categories, each describing either quietness while being awake, emotional stability, frequent anger, frequent hugging or kissing, or noisiness. For questions (f) a dichotomous variable was constructed by assigning the score 1 to those children who were afraid of the dark and 0 to those who were not. For question (g), finally, the answer categories permitted the calculation of a two-week frequency of temper tantrums. It should be noted that among the data on emotional behavior only the scores for fear of the dark and temper tantrums were obtained at a point in time close to the catecholamine measures.

*Disciplinary procedures*

The central question in the interviews about disciplinary procedures employed was:

What kinds of punishment do you use?

- (a) Smacking?
- (b) Other methods of punishment?

The answer categories with regard to 'smacking' permitted the calculation of a two-week frequency, and, thus, a frequency score was obtained for each interview and each child. In many of the cases where smacking was reported it consisted only of light physical punishment (Klackenberg-Larsson & Stensson). Of the other methods of punishment only two, 'isolation' (boy confined to separate room, not spoken to, etc.) and 'deprivation' (boy not allowed to watch TV, not allowed candy, etc.), showed a pronounced variation among families. The only quantitative measure of these variables that could be obtained was the age at which these punishments were used for the first time. This particular age was recorded also for punishment by smacking.

## RESULTS

*Catecholamine excretion in sons and parents*

Table 1 shows means and standard deviations for sons, mothers, and fathers for excretion rates of adrenaline and noradrenaline during night rest as well as for diuresis and period of excretion. Both parents had higher catecholamine excretion rates agreed fairly with the night-rest values obtained in an investigation by Bloom, Euler and Frankenhaeuser (1963) on paratroop trainees. Comparable data for children do not seem to be available in the literature. The distributions of the catecholamine-excretion scores were approximately normal with a slight tendency towards positive skewness, especially in the parents' distributions.

TABLE 1

Means and standard deviations of sons, mothers, and fathers for noradrenaline (NA), adrenaline (A), urine excretion, and period of excretion during night rest.

Variable	M	S.D.
NA, ng/min		
Son	9.58	2.89
Mother	13.36	5.75
Father	14.82	3.81
A, ng/min		
Son	0.86	0.69
Mother	1.50	0.99
Father	1.36	0.66
Urine, ml/min		
Son	0.42	0.14
Mother	0.59	0.24
Father	0.69	0.20
Period of excretion, min		
Son	642	48.2
Mother	499	57.0
Father	491	57.9

The period of excretion, which approximates the time of sleep, was longer for the boys (about 11 hours) than for their parents (about 8 hours). The urine-excretion rate was highest for the fathers and lowest for the sons.

The differences in hormone-excretion rates were submitted to tests of significance,

and the *t*- and *p*-values obtained are shown in Table 2. It is seen that (a) the differences between mothers and fathers were negligible with respect to the excretion rates of both hormones and (b) both parents had significantly higher excretion rates of both hormones than the boys. When evaluating these results it is important to keep in mind the catecholamine excretion is related to body weight (Kärki, 1956), and that the differences between excretion rates of parents and sons may merely reflect differences in body weight.

TABLE 2

*t*- and *p*-values for differences in noradrenaline (NA) and adrenaline (A) excretion, between sons (S), mothers (M), and fathers (F).

Variable	<i>t</i> -value		
	M-F	S-M	S-F
NA	-1.440	-4.107***	-7.583***
A	0.776	-3.676***	-3.625***

\*\*\* *p* < 0.001

The relationships between excretion rates of the different family members were explored further by calculating the product-moment coefficients of correlation shown in Table 3. In noradrenaline excretion there was a significant, positive correlation between mother and son, while the correlations between father and son, and between father and mother, were close to zero. In the case of adrenaline excretion there were no significant correlations between family members.

TABLE 3

Product-moment coefficients of correlation of noradrenaline (NA) and adrenaline (A) excretion rates between sons, mothers, and fathers.

	NA	
	Mother	Father
Son	.31°	-.01
Mother		.06
	A	
	Mother	Father
Son	-.08	.06
Mother		.03

° *p* < 0.05

Table 4 shows the correlations between noradrenaline and adrenaline excretion in sons, mothers, and fathers, respectively. For the mothers and fathers the correlations between the two hormones were of about the same magnitude as those reported in previous investigations from this laboratory (Frankenhaeuser et al., 1966; Pátkai et al., 1966). However, with respect of the boys the correlations were very low, a finding which might indicate that the commonly found covariation of noradrenaline and adrenaline excretion does not become established until after the age of 9 years.

TABLE 4

Product-moment coefficients of correlation between excretion rates of noradrenaline (NA), and adrenaline (A) for sons, mothers, and fathers.

	Son	Mother	Father
r <sub>NA.A</sub>	.10	.36*	.44**

\* p < 0.05  
 \*\* p < 0.01

*Catecholamine excretion and social status*

The product-moment correlations between the Graffar social score and noradrenaline and adrenaline excretion, respectively, are shown in Table 5. The noradrenaline excretion of the fathers showed a significant positive relationship with the social score, which means that there was a tendency among fathers of higher social status to excrete less noradrenaline during night rest than fathers with lower social status. With respect to adrenaline excretion there was a tendency in the same direction, but the correlation did not reach a statistically significant level. In the case of mothers and sons no significant correlations between hormone excretion and social score could be demonstrated, although there was a tendency for a negative relationship between the boys' adrenaline-excretion rate and the social status of the family ( $0.05 < p < 0.10$ ).

TABLE 5

Product-moment coefficient of correlation between the Graffar social score and excretion rates of noradrenaline (NA) and adrenaline (A). (High score indicates low social status.)

	Son	Mother	Father
r <sub>NA.Graffar</sub>	.08	-.21	.35*
r <sub>A.Graffar</sub>	-.24	-.11	.23

\* p < 0.05

*Catecholamine excretion and intelligence*

Table 6 shows the correlation coefficients between IQs recorded on two different occasions, at 5 and 8 years, and the catecholamine measures obtained at 8 to 9 years. The adrenaline excretion shows positive correlations with both IQ obtained at 5 years ( $p < 0.01$ ). Correlations between noradrenaline excretion and intelligence were close to zero. The higher correlation between the adrenaline measures and IQ at age 5 might be due simply to the fact that at age 8 the distribution was slightly positively skewed, some quotients being very high. According to Terman and Merrill (1960) extremely high scores on the scale are less reliable than medium and low scores at all age levels.

TABLE 6

Product-moment correlations between IQ (Terman-Merrill) at 5 and 8 years and excretion rates of noradrenaline (NA) and adrenaline (A) at 8 to 9 years.

Variable	Intelligence quotient	
	5 years	8 years
NA	.13	.02
A	.42**	.23

\*\* p < 0.01

*Catecholamine excretion and emotional behavior*

Table 7 shows the correlation coefficients between the variables describing emotional behavior during the first five years of life and excretion rates of noradrenaline and adrenaline at the age of 8 to 9 years. The correlations are, on

the whole, low, and no consistent tendencies can be distinguished. The only statistically significant relationship was the negative correlation between noradrenaline excretion ( $p < 0.01$ ) and the variable 'quiet while awake' as assessed during the first 18 months of life. The fact that noradrenaline excretion was negatively related also to the variable denoted 'noisy' is not necessarily contradictory, since the two variables describe different kinds of quietness and noisiness, respectively, and the measures refer to different periods of life.

TABLE 7

Product-moment correlations between noradrenaline (NA) and adrenaline (A) excretion in 8 to 9 year old boys and emotional behavior during different periods of the first 5 years of their lives.

Variable	NA	A
Quiet while awake	-.39**	-.17
Emotionally stable	-.07	.05
Angry	-.07	-.05
Affectionate	-.01	.01
Noisy	-.22	.06

\*\*  $p < 0.01$

Table 8 shows the correlations between emotional behavior at 8 years and catecholamine excretion at 8 to 9 years. There was a statistically significant correlation between adrenaline excretion and the frequency of temper tantrums ( $p < 0.05$ ). The correlation between adrenaline excretion and the variable 'afraid of the dark' was also positive, but did not reach a significant level. No relationships between noradrenaline excretion and emotional behavior were demonstrated.

TABLE 8

Product-moment correlations between noradrenaline (NA) and adrenaline (A) excretion in 8 to 9 year old boys and two indicators of emotional behavior assessed at the age of 8 years.

	Afraid of the dark	Temper tantrums
NA	.00	-.09
A	.20	.29*

\*  $p < 0.05$

*Catecholamine excretion and disciplinary procedures*

A correlation matrix in Table 9 shows the frequency of smacking administered

TABLE 9

Product-moment correlations between noradrenaline (NA) and adrenaline (A) excretion of sons (S), mothers (M), and fathers (F) and the two-week frequency of smacking incidents during different periods of the boys' early childhood.

Smacking frequency	NA S	NA M	NA F	A S	A M	A F
Smacking by mother:						
1st year	.01	-.05	-.08	-.12	-.15	-.12
2nd year	-.09	-.22	-.17	-.19	.10	-.12
3rd year	.02	.02	-.25	-.17	.21	-.04
first 3 years	-.05	-.13	-.19	-.20	.05	-.12
first 5 years	-.09	-.16	-.22	-.22	.01	-.13
at 8 years	-.02	.18	-.07	.01	.21	-.14
Smacking by father:						
1st year	.13	.04	-.22	-.08	-.14	-.06
2nd year	-.14	-.08	-.29*	.00	.37**	-.15
3rd year	.01	-.14	-.14	-.03	.33*	.05
first 3 years	-.01	-.08	-.32*	-.06	.24	-.10
first 5 years	.01	-.05	-.30*	-.08	.26	-.06
at 8 years	-.07	.12	-.11	.05	.20	-.21

\*  $p < 0.05$

\*\*  $p < 0.01$

by mother and father during different ages of their boys' lives as related to the present-day catecholamine measures obtained from sons, mothers, and fathers. Most of the coefficients were low and there was no completely consistent pattern. However, the tendencies that can be distinguished seem to indicate that the father's, rather than the mother's, indulgence in smacking may be related to the catecholamine excretion of the various family members. Thus, there was a significant negative correlation between the father's noradrenaline excretion and the frequency at which he smacked his son before the age of five. Furthermore, the frequency of smacking by the father was positively correlated with the rate of adrenaline excretion by the mother.

Table 10 shows correlations between the boys' excretion rates of noradrenaline and adrenaline, and the age of the boy at which punishment (smacking, isolation, or deprivation) was reported by the mother for the first time. Only two of the coefficients reached statistical significance showing (a) that boys who were frequently smacked early in their lives had a lower excretion rate of adrenaline at the age of 8 to 9 years than those who received such punishment later, and (b) that boys who were punished by isolation at an early age had a lower excretion rate of noradrenaline at the age of 8 to 9 than those who were only later so punished.

TABLE 10  
 product-moment correlations between noradrenaline (NA) and adrenaline (A) excretions of the boys and the age at w/c different punishments were used for the first time.

	The son's age at the first report of		
	At least daily smacking by mother	Isolation	Deprivation
NA	-.01	.35*	.13
A	.37**	.03	.06

\* p < 0.05  
 \*\* p < 0.01

COMMENTS

The present investigation enters into the relatively unexplored area of relationships between hormone activity and factors concerning development and social ecology. Of particular interest was the finding that the noradrenaline excretion of the boys was significantly and positively correlated with that of their mothers but not with that of their fathers. This relationship may have a genetic origin, or it may be associated with environmental factors and reflect a close behavioral and emotional relationship between mother and son at the age level studied. A closely related problem is the interaction between catecholamine release and the disciplinary procedures employed by the parents. The present results point to

some interesting relationships, such as a negative correlation between the fathers' noradrenaline-excretion rate and the frequency with which he smacks his son during the first five years. The trend showing a consistent positive relationship between the mothers' adrenaline excretion and fathers' smacking frequency from the second year of their son's lives is also highly interesting. Possible interpretations of these relations and of the correlations found between catecholamine excretion and other data on punishment and behavior have been discussed elsewhere by Lambert et al. (Lambert, Klackenberglarsson, Frankenhaeuser & Johansson, 1967; Lambert, Sampson, Wolf & Wolf, in preparation). It is hoped that additional information will be gained in a parallel investigation on girls and their

parents, and when these data have been collected we shall attempt to evaluate the complex interactions between hormone release and social, behavioral, and developmental factors.

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