HORMONES AND BEHAVIOR 12, 60–72 (1979)

ACTH-Induced Excessive Grooming in the Rat: The Influence of Environmental and Motivational Factors

J. JOLLES, J. ROMPA-BARENDREGT, AND W. H. GISPEN

Division of Molecular Neurobiology, Rudolf Magnus Institute for Pharmacology, and Laboratory of Physiological Chemistry, Medical Faculty, Institute of Molecular Biology, State University of Utrecht, Padualaan 8, Utrecht, The Netherlands

Intraventricularly administered $ACTH_{1-24}$ in rats initiated excessive grooming followed by stretching and yawning syndrome. The present study provides evidence that novelty is not an essential prerequisite for its expression and that a variety of environmental variables is not able to influence the peptide-induced behavior. Only very strong motivational variables as severe hunger/thirst and anxiety are able to modulate the ACTH-initiated excessive grooming: This response is significantly depressed in water-deprived rats bar pressing for water in a Skinner box, as well as in rats receiving unavoidable electric foot shock. The results are indicative of the strength of the ACTH-initiated motivation to groom, and it is suggested that excessive grooming is a secondary response serving to dearouse the organism after activation by ACTH.

Intraventricular administration of pituitary hormones such as ACTH, MSH (Ferrari, Gessa, and Vargiu, 1963; Gispen, Wiegant, Greven, and de Wied, 1975) and β-endorphin (Gispen, Wiegant, Bradbury, Hulme, Smyth, Snell, and de Wied, 1976) induces excessive grooming in the rat. This excessive grooming can be elicited in adrenalectomized, hypophysectomized, or gonadectomized animals (Gispen *et al.*, 1975). ACTH fragments devoid of classical endocrine activity also have grooming-inducing activity; structure–activity studies show that the active part resides in the sequence $ACTH_{4-7}$ (Wiegant and Gispen, 1977). Recent evidence suggests that dopaminergic projections are involved (Cools, Wiegant, and Gispen 1978). Following intraventricular administration, ACTH also induces a stretching and yawning syndrome (SYS), first described by Ferrari *et al.* (1963). This response always accompanies ACTH-induced grooming although different pathways seem to be involved (Colbern, Isaacson, Bohus, and Gispen, 1977).

In the organization of spontaneous grooming behavior both peripheral and endogenous regulation is involved (Rowell, 1961; Swenson and Randall, 1977; Baillie and Morrison, 1963; Ewer, 1967; Fentress, 1973). In mammals, especially rodents, grooming is sometimes considered to re-

0018-506X/79/010060-13$01.00/0

flect a thermoregulatory response (Adolph, 1947; Hainsworth and Epstein, 1966; Hainsworth, 1967) but it may also occur as a reaction to unexpected stimuli (Fentress, 1968a,b), in conflict situations (Rowell, 1961; van Ierssel and Bol, 1958) or in frustration (McFarland, 1966). This stress- and conflict-related grooming is often described as displacement activity (Tinbergen, 1940; Sevenster, 1961). Common factor in these situations seems to be the presence of potentially stressing or novel stimuli or stimuli that bear conflicting information.

Recently we provided evidence that displacement grooming cannot be explained as maintenance grooming. The results suggested that the observed displacement grooming was primarily related to the state of arousal/activation of the animal (Jolles, Rompa-Barendregt, and Gispen, 1979).

In the present study we report experiments on the role of environmental and motivational factors in ACTH-induced excessive grooming.

METHODS

Subjects and general experimental procedure. Male rats of an inbred Wistar strain were used (TNO, Zeist, The Netherlands). They were bred in our own colony and weighed 140–150 g at the commencement of the experiment. The animal rooms were kept at a 12 h light/12 h dark schedule (8.00 hr AM/8.00 hr PM). All experimental animals were housed individually in plastic boxes (23 × 17 × 13 cm) with woodshavings, for 1 week prior to the experimental day. The rats were handled every second day. Cannulation of the brain ventricular system took place 1 week before the experimental day. All experiments were performed between 10.00 hr AM and 3.00 hr PM. On the experimental day a standard grooming test was run as follows: Ten cages were transported from the animal room to the behavior observation room. This transport took 2–4 min. Then the rats received an intraventricular injection after which they were subjected to the behavioral analysis in a dimly lit soundproof observation room. Observation was carried out through a one-way mirror. Eight to ten rats were observed simultaneously.

Surgery and injections. A polyethylene cannula was implanted into the foramen interventriculare as described previously (Colbern *et al.*, 1977). Synthetic $ACTH_{1-24}$ (Organon Int.b.v., Oss, The Netherlands) was dissolved in saline, stored at −20°C for 4–6 weeks, and thawed 15 min prior to use. Intracerebroventricular injections were made by free hand into the conscious rats by using a microsyringe (Unimetrics Corp.) (Colbern *et al.*, 1977). Injection volume was 3 μl containing 1 μg of peptide. Saline (3 μl) was the control solution.

Behavioral analysis. After manipulation (injection) the rats were placed individually into glass boxes (24 × 12.5 × 14 cm). This moment marked

the beginning of the behavioral session. Maintenance behavior was recorded between 15 and 65 min thereafter as described previously (Gispen *et al.*, 1975; Colbern *et al.*, 1977) unless stated otherwise. In short, every 15th sec the observer recorded whether the animal displayed an element of the maintenance repertoire (vibrating, washing, grooming, scratching, licking body, licking paw, licking tail). Since the predominant element recorded is grooming, we refer to grooming in keeping with previous reports (Gispen *et al.*, 1975,1976). Thus, in a 50-min observation period a maximum of 200 positive grooming scores can be obtained provided one scores every 15th sec. Scores are given as the percentage of this maximum possible grooming score. The validity of this time sampling technique has been established elsewhere (Gispen *et al.*, 1975).

Novelty and habituation. The novelty condition involved the standard procedure including transportation and placement of the subject into a novel observation box. Animals observed in the home environment were not transported and after icv injection were placed back into their home cage in the animal room. Habituation involved the daily exposure of the rat to the entire procedure including a sham icv injection. The habituation procedure was carried out during 4 days prior to the observation session. Chronic treatment involved only the daily icv injection of $ACTH_{1-24}$ (1 μg/3 μl) for 4 days prior to the observation session. As an index of "emotionality" produced by experimental treatment, urination/defecation scores were taken as described by Broadhurst (1960). A positive score was assigned to that animal that urinated and/or defecated during the manipulation or within 2 min thereafter.

Enriched environment. In the enriched environment condition the rats were observed in a large glass box (58 × 38 × 30 cm) with woodshavings. The box contained an unknown, untreated other male rat, a running wheel, and four objects which could be walked in or climbed over.

Food and water deprivation. Rats were deprived from food and water during 48 hr preceding the experiment. Drinking and eating during the observation period was measured by using a 15th sec sampling procedure. Every 15th sec the observer recorded whether or not the rat was engaged in eating or drinking.

Skinner box training. Skinner box training was performed using a Campden Instruments rodent test chamber (Model 441) with a liquid dipper feeder. Rats were deprived from water for 36 hr prior to the first Skinner box training. There was one training session every day and they were allowed to drink *ad libitum* for a restricted amount of time (1 hr) after each session providing a constant amount of water deprivation throughout the experiment. The rats were shaped to press the lever. After reaching criterion on a continuous reinforcement schedule they were trained on a Fixed Ratio schedule. All rats reached criterion (FR 5) within

7 days. After another 5 days of training they were cannulated. There was 1 week between cannulation and experimental day during which time the animals received their usual training.

There were 2 experimental days. Half of the group was treated with ACTH on the first day and with saline on the second, the other half was treated vice versa. After icv injection the animal was placed back into the homecage for 15 min and following that interval the animal was put into the Skinner box and behavioral analysis began.

Inescapable foot-shock training. The apparatus consisted of six experimental chambers measuring 25 × 24 × 18 cm with a stainless-steel grid floor and with an electric buzzer on top. Foot-shocks of 1.5 mA and 2-sec duration were delivered to the grid floor by a Grason–Stadler shock generator (E 1064 GS). Three different treatments were given: (1) In the CS condition a buzzing tone (conditioned stimulus, CS) of 8-sec duration was presented at fixed intervals after the start of the experimental session (t = 23, 32.5, 37, 39.5, 44, 51, 53.5, 58, and 65 min). (2) In the CS + UCS condition in addition to the CS an unavoidable foot-shock (unconditioned stimulus UCS) was delivered through the grid floor at t = 23, 32.5, 39.5, 44, and 58 min. The shock was presented upon termination of the tone. (3) In the UCS condition only the shock was delivered as described under condition (2). No CS was presented.

Statistics. Differences between groups were tested with the Kruskal–Wallis one-way analysis of variance and Mann Whitney U test (Siegel, 1956) and were assigned to be significant for $P < 0.05$; two-tailed.

RESULTS

ACTH-Induced Grooming and Novelty

To study whether ACTH-induced excessive grooming is dependent on the presence of novel and potentially stressful and/or arousing stimuli, ACTH-injected rats were studied in experimental conditions found to discriminate between novelty and non-novelty situations (Jolles *et al.*, 1978).

Five groups of male rats were used that differed in one or more variables from standard treated rats (transport to novel room, injection, transfer to novel box in soundproof room, see Methods).

The amount of ACTH-induced grooming was the same whether or not rats were observed in a novel or home environment (90% from maximum possible score). Neither habituation to the experimental treatment nor chronic pretreatment of the animal had an effect on ACTH-induced grooming. Also habituation to the novel environment alone had no effect. Only rats exposed to the standard novel treatment showed a positive urination/defecation score used as a measure of their emotionality. According to this criterion the other groups displayed hardly any emotional-

ity. These data indicate that novelty/stress is not a necessary prerequisite for the manifestation of ACTH-induced grooming.

ACTH-Induced Grooming and Enriched Environment

The standard grooming test procedure presents the animal with an environment in which few behavioral alternatives are provided. Therefore the hypothesis was tested that ACTH-induced excessive grooming is related to an experimental situation favoring self-directed behavior. ACTH- and saline-treated rats received a standard experimental treatment. Their grooming behavior was recorded in a standard or an enriched environment (see Methods).

ACTH-induced grooming was not influenced by the nature of the observation box in which the animals were observed: ACTH-induced grooming scores were the same whether the rat was observed in the standard environment or in a large box with a partner rat, and with objects it is used to play with. Whether the animals were familiar with cage and objects or exposed to them for the first time did not affect the grooming response (data not shown).

Saline-treated rats displayed a similar amount of grooming in either the standard or the enriched environment. However, the temporal pattern of the grooming behavior was not identical. Animals in the enriched environment immediately after the injection started to explore the observation box before engaging in grooming behavior. This group displayed significantly less grooming in the period from 0–15 min after injection than the standard saline group (results not shown). ACTH-treated rats showed a similar but not significant tendency when tested in the enriched environment. Taken together the results indicate that the ACTH-induced excessive grooming response is also present in a situation in which the animal has several behavior alternatives. Thus, ACTH does not simply urge the animal to enhance and prolong any behavior it is engaged in.

ACTH-Induced Excessive Grooming and Food and Water Deprivation

In this experiment the influence of strong motivational factors on ACTH-induced grooming behavior was studied. It was decided to use food and water deprivation as the experimental variable; when a deprived animal is provided with food and water, eating and drinking have a high response probability (McFarland, 1971) and these behaviors may therefore serve as potent alternatives for peptide-induced grooming.

As is shown in Fig. 1, the ACTH-induced grooming was unaffected by food and water deprivation (group 1 vs 2), and delivery of food and water during the experiment did not reduce total grooming scores (group 3 vs 4).

Saline-treated water-deprived rats, however, groomed significantly less than nondeprived animals (group 5 vs 6; $P < 0.05$): These rats are dehydrated and spend less time grooming, to conserve water which is

GROUP	TREATMENT deprivation†	injection*	food▽/water	N	GROOMING SCORE△ (20 40 60 80 100)	W
1		ACTH		5		6
2	+	ACTH		8		15.5
3		ACTH	+	11		16.5
4	+	ACTH	+	11		16.5
5		saline		6		7
6	+	saline		6		7.5
7		saline	+	15		23.5
8	+	saline	+	12		12.5
9	+	ACTH	+	9		10
10	+	saline	+	6		7.5

FIG. 1. Grooming behavior: The effect of food and water deprivation. A grooming test was given in the standard impoverished environment (groups 1–8) or in a Skinner box (groups 9 and 10).
(*N*) Number of animals.
(Δ) Grooming score (median) is the percentage of the maximum possible score.
(W) Interquartile Range.
(†) Groups 1–8 were deprived of food and water for 48 hr preceding the grooming test: Groups 9 and 10 were maintained on a constant level of water deprivation for 3 weeks prior to the grooming test and were subjected to a Skinner box training session each day.
(*) The ACTH groups received an icv injection of 1 μg ACTH in 3 μl saline. The other groups received 3 μl saline.
(▽) Groups 3, 4, 7, and 8 were given food and water at $t = 30$ min (30 min after injection, 15 min after start of the behavior observation). Groups 9 and 10 had access to water at $t = 15$ min (15 min after injection, the moment they were placed in the Skinner box).

otherwise lost by licking and saliva spreading (Ritter and Epstein, 1974). When saline-treated deprived rats got food and water during the observation (see Fig. 2) they spent nearly all of their time eating and drinking and consequently their eating/drinking scores were significantly higher than scores of the corresponding control group (group 7 vs 8; $P < 0.001$). Also the eating/drinking scores in ACTH-treated animals differed between nondeprived and deprived rats (group 3 vs 4; $P < 0.01$), indicating that ACTH-treated, deprived animals were motivated to eat and drink. ACTH-treated deprived rats were observed to eat and drink for only 5–7 min after the presentation of food and water and then gradually excessive grooming was displayed again. Apparently in this *ad libitum* feeding situation the period of eating and drinking by deprived animals was too short to clearly reduce the total amount of ACTH-induced grooming.

If, however, water-deprived animals were trained to obtain water by pressing a bar in a Skinner box, upon treatment with ACTH the grooming score was only 65%. Such rats groomed significantly less than standard treated rats (group 1 vs 9; $P < 0.01$); their total grooming scores, however, were still significantly enhanced as compared to saline-treated control animals (group 9 vs 10; $P < 0.01$). Drinking scores of the ACTH-treated

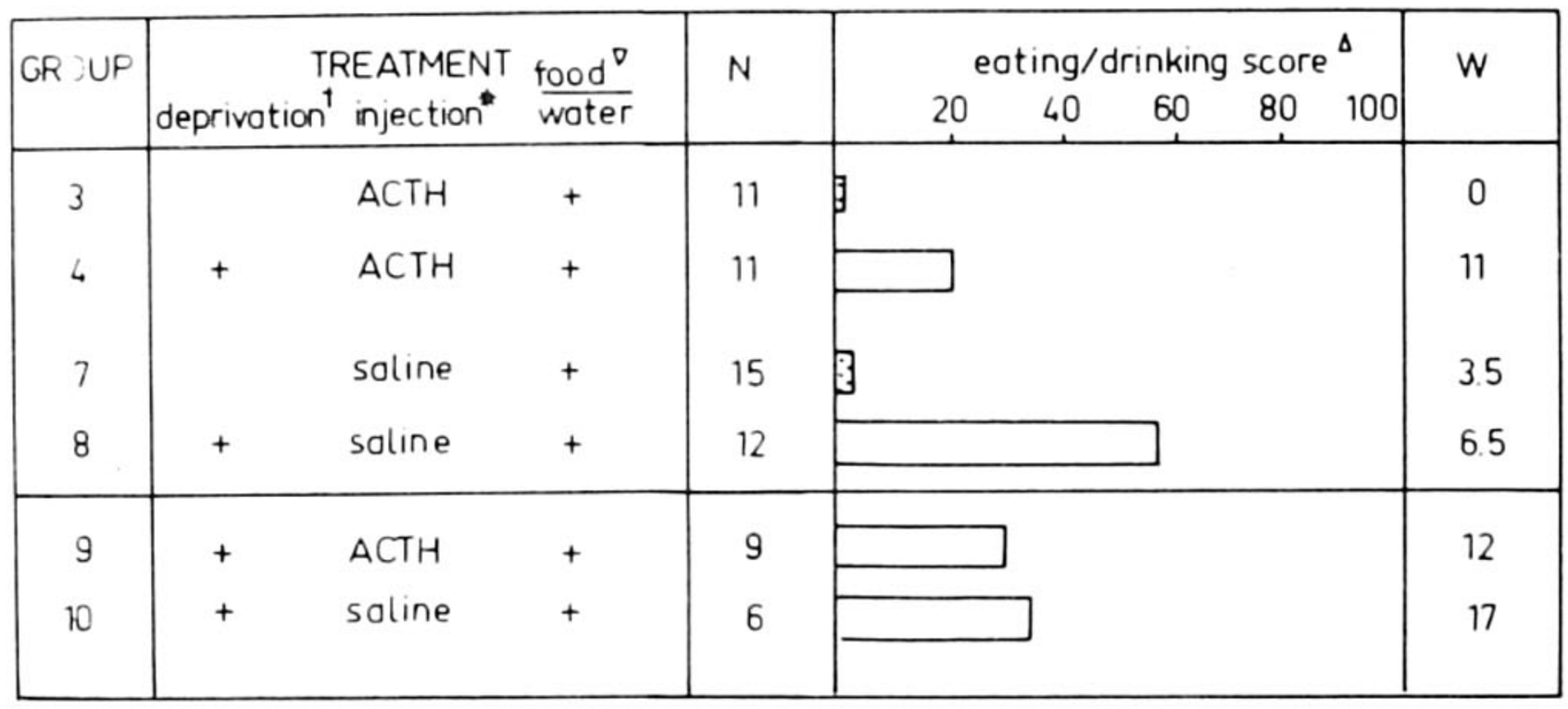

FIG. 2. Eating and drinking scores in ACTH- and saline-treated rats. Eating and drinking scores correspond to the grooming scores depicted in Fig. 1. The bars represent the percentage of maximum possible eating and drinking scores. For treatment and symbols see legend to Fig. 1.

rats were the same as those of saline-treated controls. The temporal pattern of grooming behavior is shown in Fig. 3: It depicts cumulative scores for representative rats in both the saline and the ACTH condition in the Skinner box and in the standard observation box. After treatment with ACTH in the standard observation box the rats displayed a very consistent grooming pattern, only interrupted for a period of 5–10 min, in which they displayed the stretching and yawning syndrome (see Gispen *et al.*, 1975). In the Skinner box, however, the ACTH-treated animals started by drinking for 10–15 min and only gradually began to groom. It appeared that periods of grooming and drinking alternated. The time spent on grooming plus drinking was the same as that spent on grooming in the standard observation box. In the Skinner box the saline-treated animal started by drinking for 20–25 min and during this period it gradually began to groom. Total grooming scores were higher than in the corresponding standard observation box. The rats did not fall asleep but they were active during the total 60 min of the observation period. These results indicate that it is possible to influence the amount and temporal pattern of ACTH-induced excessive grooming by the proper use of a potent behavioral alternative.

ACTH-Induced Excessive Grooming and Inescapable Foot-Shock

To investigate whether the grooming response can be blocked completely by behavioral manipulation, we exposed animals to inescapable foot-shock during the excessive grooming test and studied the influence of training to this aversive treatment.

Seven groups of rats were used. They received a standard grooming test (Methods) in a situation allowing the delivery of a moderate electric foot-shock (unconditioned stimulus, UCS). A buzzer served as conditioned stimulus (CS, see Methods). Figure 4 gives a cumulative plot of grooming scores of representative rats under the different conditions:

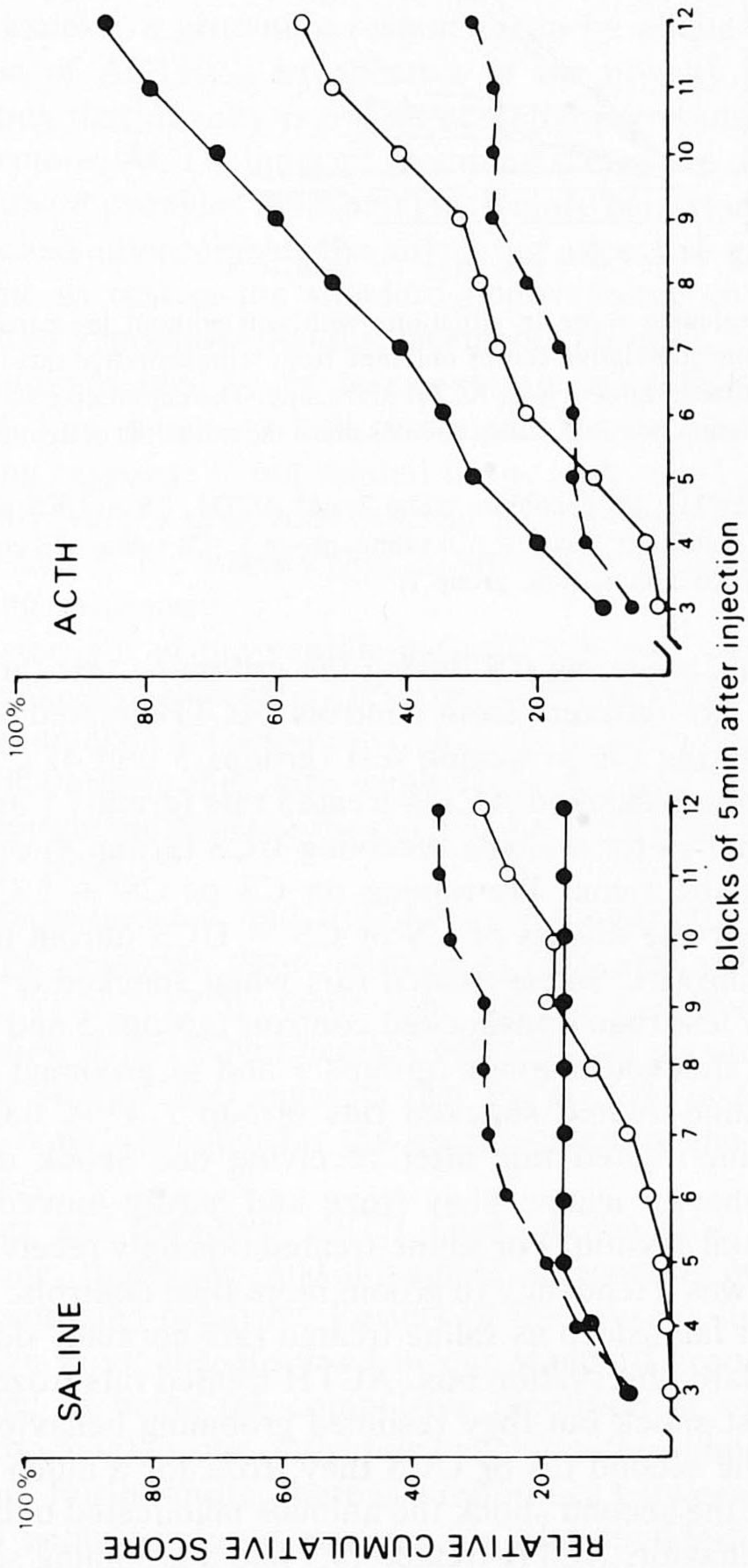

FIG. 3. Cumulative grooming/drinking score in standard box vs Skinner box. Scores for representative rats in either standard box or Skinner box for both saline-treated and ACTH-treated rats. The cumulative score gives the percentage of the maximum possible score.
(●- - -●) Drinking scores in the Skinner box;
(○——○) Grooming scores in the Skinner box;
(●——●) Grooming scores in the standard test box.

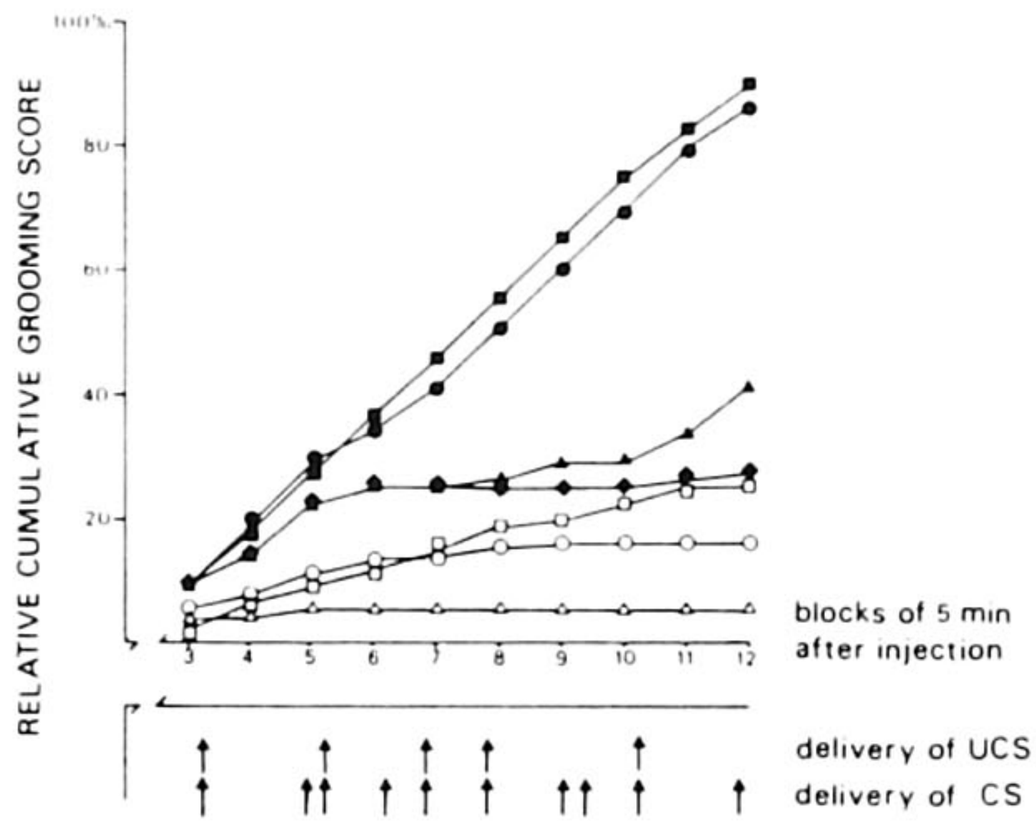

FIG. 4. Cumulative grooming score in situations with and without inescapable foot shock. The figure represents cumulative scores obtained from representative rats in shock/nonshock conditions and after treatment with ACTH and saline. The cumulative score gives the percentage of the maximum possible score. Arrows mark the moments of delivery of CS and/or UCS.

(●) ACTH, group 1; (■) ACTH, CS condition, group 2; (▲) ACTH, CS + UCS condition, group 3; (◆) ACTH, UCS condition, group 4; (○) saline, group 5; (□) saline, CS condition, group 6; (△) saline, CS + UCS condition, group 7.

ACTH-treated animals receiving CS during the grooming test (group 2) had grooming scores not different from controls. ACTH-treated animals that were shocked during the grooming test (groups 3 and 4) groomed significantly less than nonshocked ACTH-treated rats (groups 1 and 2; $P < 0.02$). Grooming scores for animals receiving UCS (group 4) or CS + UCS (group 3) were the same. Pretraining on CS or CS + UCS (see Methods) did not alter the effects of CS or CS + UCS during the test session (results not shown). Saline-treated rats when shocked (group 7) groomed significantly less than nonshocked controls (groups 5 and 6; $P < 0.01$) ACTH-treated shocked animals (groups 3 and 4) groomed significantly more than saline-treated shocked rats (group 7, $P < 0.01$). As shown in Fig. 4 saline-treated rats after receiving one shock did not resume grooming behavior again. They froze and hardly moved at all during the experimental session. For saline-treated rats only receiving CS during the test there was a tendency to groom more than controls: In fact these animals did not fall asleep as saline-treated rats normally do when observed in the standard observation box. ACTH-treated rats froze when they received the first shock but they resumed grooming behavior after about 4 min. After the second CS or UCS they froze for a much longer period of time. After the second shock the animals manifested only short bouts of grooming behavior. ACTH-treated rats had a grooming score of 22% before the second shock and about 4–20% after the second shock (Fig. 4). Saline-treated rats groomed 0% after the second shock. Therefore, it seems that ACTH-induced grooming is not totally inhibited by the experimental treatment. Thus, presentation of inescapable foot-shock

blocks ACTH-induced grooming to a vast amount but not completely, again indicating the strength of the ACTH-induced motivation to groom.

DISCUSSION

The excessive grooming response can be elicited by intraventricular injection of $ACTH_{1-24}$ irrespective of the novelty of the environment, suggesting that novelty is not an essential prerequisite for the response. Furthermore, ACTH-induced grooming scores are not affected when the environment provides the animal with more behavioral alternatives for, in an enriched environment, the amount of excessive grooming elicited was the same as that in the standard impoverished environment. This disproves the hypothesis that displacement grooming induced by the lack of information yielded by the test environment (Jolles *et al.*, 1978; Sevenster, 1961) is enhanced and prolonged by the peptide: The excessive grooming response is not related to the lack of behavior alternatives. In fact, only very strong motivational factors as severe thirst and hunger (Figs. 1 and 3) and anxiety (Fig. 4) are able to interfere with the excessive grooming response.

The strength of the peptide-induced behavior is reflected by the fact that the excessive grooming response is displayed by water-deprived rats: As these animals are dehydrated they are less likely to engage in grooming behavior because they lose water by licking and saliva spreading which are important elements of the maintenance behavior repertoire (Ritter and Epstein, 1974).

Adrenalectomized and hypophysectomized rats show the excessive grooming response upon intraventricular administration of $ACTH_{1-24}$ (Gispen *et al.*, 1975), while rats when not stressed or anxious after habituation to the experimental treatment still manifest excessive grooming (this study). This suggests that the activity of the pituitary–adrenal system is not essential for the manifestation of the excessive grooming response.

Ayhan and Randrup (1973) have shown that high doses of amphetamine, morphine, and dopamine antagonists may induce a stereotyped grooming behavior. Results of the present study suggest that the excessive grooming observed in our standard grooming test cannot be explained as being the compulsive repetition of self-directed behavior (i.e., grooming) as one of the few behaviors the animal can display in that situation. Furthermore, there is a difference between stereotyped grooming and peptide-induced grooming in that peptide-treated rats display a behavioral repertoire that has all the characteristics of the normal repertoire, only duration and intensity being enhanced (Gispen *et al.*, 1975). Drug-induced stereotyped grooming is characterized by the compulsive repetition of only one element of the behavioral repertoire.

The results obtained in a twin study on the relation between novelty and grooming (Jolles *et al.*, 1979) suggested that novelty/stress as such is only of secondary importance in inducing displacement grooming. The state of activation/arousal of the animal was suggested to be the prime determinant; animals displayed enhanced grooming when activated by a treatment before or during the observation period. Results of the present study are in line with this hypothesis as rats kept awake during the observation session (Figs. 2 and 4) manifest higher grooming scores.

It could be that ACTH adds to arouse/activate the organism; excessive grooming then is a secondary response of the organism lowering the state of arousal and thereby serving homeostasis. Evidence in support of the grooming–dearousal notion can be found in various studies. Delius (1970; Delius, Craig, and Chaudoir, 1976) concluded from electrophysiological data that grooming behavior is a dearousal mechanism serving homeostasis. Displacement activities would reflect the external consequence of an activated arousal-inhibiting system. Indeed it was found that pigeons showed drowsiness associated with the EEG signs of lowered wakefulness as response to a novel environment and a frustrating and fear-producing procedure. This was often accompanied by comfort movements as yawning, stretching, grooming, etc. before the birds became active again (Delius *et al.*, 1976). Many studies point to direct effects of ACTH on the brain (see de Wied and Gispen, 1977). Electrophysiological evidence revealed an influence of ACTH on activity of midbrain limbic structures. Urban and de Wied (1976) suggested that ACTH increases the state of electrophysiological arousal of certain brain structures which may determine the motivational value of environmental stimuli. Furthermore, ACTH seems to have a specific effect on a CNS-vigilance regulating system (Wolthuis and de Wied, 1976). Bohus (1975) found that administration of $ACTH_{4-10}$ which increases avoidance latencies in a one trial passive avoidance situation, was associated with tachycardia. According to Bohus (1975) this tachycardic response may be coupled with generalized arousal. Already in 1932, Cannon described grooming behavior as a very important behavior serving homeostasis, because it keeps the boundary between internal and external milieu in good condition (Cannon, 1932). Other studies implicate ascending dopaminergic (Cools *et al.*, 1979) and noradrenergic (Ayhan and Randrup, 1973) fibers, known to be involved in arousal and attention, in grooming behavior. Thus activated arousal mechanisms may underlie the effect of ACTH on grooming behavior (Jolles *et al.*, 1979; this study) and on the extinction of learned behavior (Bohus, 1975).

Taken together, these studies are in line with the view that excessive grooming is a secondary response serving to dearouse the organism after activation by ACTH. It remains to be shown whether factors known to induce displacement grooming act via endogenously released ACTH.

ACKNOWLEDGMENTS

The authors wish to thank Drs. D. de Wied and J. L. Slangen for valuable suggestions and discussions and Mr. J. H. Brakkee for his indispensable technical assistance.

REFERENCES

Adolph, E. F. (1947). Toleration to heat and dehydration in several species of mammals. *Amer. J. Physiol.* **151,** 564–575.

Ayhan, I. H., and Randrup, A. (1973). Behavioral and pharmacological studies on morphine-induced excitation of rats. Possible relation to brain catecholamines. *Psychopharmalogia (Berlin)* **29,** 317–328.

Baillie, P., and Morrison, S. D. (1963). The nature of the suppression of food intake by lateral hypothalamic lesions in rats. *J. Physiol. (London)* **165,** 227–245.

Bohus, B. (1975). Pituitary peptides and autonomic responses. *In* W. H. Gispen, Tj. B. van Wimersma Greidanus, and D. de Wied (Eds.), *Hormones, Homeostatis and the Brain,* Elsevier, Amsterdam; *Progr. Brain Res.* **42,** 275–283.

Broadhurst, P. L. (1960). Experiments in psychogenetics: Applications of biometrical genetics to behaviour. *In* H. J. Eysenck (Ed.), *Experiments in Personality,* Vol. I, pp. 1–102. Routledge & Kegan Paul, London.

Cannon, W. (1932). *The Wisdom of the Body.* Norton, New York.

Colbern, D., Isaacson, R. L., Bohus, B., and Gispen, W. H. (1977). Limbic midbrain lesions and ACTH-induced excessive grooming. *Life Sci.* **21,** 393–402.

Cools, A. R., Wiegant, V. M., and Gispen, W. H. (1978). Distinct dopaminergic systems in ACTH-induced grooming. *Eur. J. Pharmacol.*, 265–268.

Delius, J. D. (1970). Irrelevant behavior, information processing and arousal homeostatis. *Psychol. Forsch.* **33,** 165–188.

Delius, J. D., Craig, B., and Chaudoir, C. (1976). Adenocorticotropic hormone, glucose and displacement activities in pigeons. *Z. Tierpsychol.* **40,** 183–193.

Ewer, R. F. (1967). The behavior of the African giant rat (*Cricetomys gambianus* Waterhouse) *Z. Tierpsychol.* **24,** 6–79.

Fentress, J. C. (1968a). Interrupted ongoing behaviour in two species of vale (*Microtus agrestis* and *Clethrionomys brittannicus*). I. Response as a function of preceding activity and the context of an apparently irrelevant motor pattern. *Anim. Behav.* **16,** 135–153.

Fentress, J. C. (1968b). Interrupted ongoing behaviour in two species of vale (*Microtus agrestis* and *Clethrionomys brittannicus*). II. Extended analysis of motivational variables underlying fleeing and grooming behaviour. *Anim. Behav.* **16,** 154–167.

Fentress, J. C. (1973). Development of grooming in mice with amputated forelimbs. *Science* **179,** 704–705.

Ferrari, W., Gessa, G. L., and Vargiu, L. (1963). Behavioral effects induced by intracisterally injected ACTH and MSH. *Ann. N.Y. Acad. Sci.* **104,** 330–345.

Gispen, W. H., Wiegant, V. M., Bradbury, H. F., Hulme, E. C., Smyth, D. G., Snell, C. R., and de Wied, D. (1976). Induction of excessive grooming in the rat by fragments of lipotropin. *Nature (London)* **264,** 794–795.

Gispen, W. H., Wiegant, V. M., Greven, H. M., and de Wied, D. (1975). The induction of excessive grooming in the rat by intraventricular application of peptides derived from ACTH: Structure activity studies. *Life Sci.* **17,** 645–652.

Hainsworth, F. R., and Epstein, A. N. (1966). Severe impairment of heat-induced saliva-spreading in rats recovered from lateral hypothalamic lesions. *Science* **153,** 1255–1257.

Hainsworth, F. R. (1967). Saliva spreading, activity and body temperature regulation in the rat. *Amer. J. Physiol.* **212,** 1288–1292.

van Iersel, J. J. A., and Bol, A. C. (1958). Preening of two tern species: A study on displacement activities. *Behaviour* **13,** 1–88.

Jolles, J., Rompa-Barendregt, J., and Gispen, W. H. (1979). Novelty and grooming behavior in the rat. *Behav. Neural. Biol.* **25,** 563–572.

McFarland, D. J. (1966). The role of attention in the disinhibition of displacement activity. *Q. J. Exp. Psychol.* **18,** 19–30.

McFarland, D. J. (1971). *Feedback Mechanisms in Animal Behavior,* Academic Press, London.

Ritter, R. C., and Epstein, A. N. (1974). Saliva lost by grooming: A major item in the rat's water economy. *Behav. Biol.* **11,** 581–585.

Rowell, C. H. F. (1961). Displacement grooming in the chaffinch. *Anim. Behav.* **9,** 38–63.

Sevenster, P. (1961). A causal analysis of a displacement activity. *Behaviour Suppl.* **9,** 1–170.

Siegel, S. (1956). *Nonparametric Statistics.* McGraw–Hill, New York.

Swenson, R. M., and Randall, W. (1977). Grooming behavior in cats with pontile lesions. *J. Comp. Physiol. Psychol.* **91,** 213–326.

Tinbergen, N. (1940). Die Übersprungbewegung. *Z. Tierpsychol.* **4,** 1–40.

Urban, I., and de Wied, D. (1976). Changes in excitability of the theta generating substrate by $ACTH_{4-10}$ in the rat. *Exp. Brain Res.* **24,** 325–334.

de Wied, D., and Gispen, W. H. (1977). Behavioral effects of peptides. *In* H. Gainer (Ed.), *Peptides in Neurobiology,* pp. 397–448. Plenum, New York.

Wiegant, V. M., and Gispen, W. H. (1977). ACTH-induced excessive grooming behavior in the rat, latent activity of $ACTH_{4-7}$. *Behav. Biol.* **19,** 554–558.

Wolthuis, O. L., and de Wied, D. (1975). ACTH analogues on motor behavior and visual evoked responses in rats. *In Abstracts of the Vth Annual Meeting of the American Society of Neuroscience,* Abstract No. 776, p. 504.