For assessing sex-related differences in rotational movements (as hinted in figure 1) further experiments would be required to decide whether females do indeed show fewer turnings than males and whether isolation-induced increases are less pronounced in females. In such studies video-taping should replace the relatively crude "recording-by-hand-technique", as with a more sensitive method it would become possible to obtain more information about the fine structure of rotational movements, and possibly get more quantifiable parameters. Such detailed characterisation was impossible in the present study due to the high velocity of rotational movements.

From a neurochemical point of view, it is tempting to speculate that these rotational movements could be caused by a brain assymetry, an imbalance in the dopaminergic system, for example, as extensive literature exists on rotational behavior and lesions in this neuro-transmitter system. To the best of our knowledge, no reports exist in which determinations of any neurochemical metabolite per hemisphere were carried out in differently housed rats. It would, however, be of interest to test whether individual housing could induce an imbalance. It should be added here, in any case, that we observed that the same individual might rotate in both directions; this finding would not favor a neurochemical explanation for the observed movements.

A final comment should be added in regard to lesion- and pharmacologically induced turning behavior. It has been reported that the magnitude of spontaneous and D-amphetamine-induced rotations in rats were highly correlated[8]. Since we have observed that an animal's environment can influence the amount of rotational movements, attention should be paid to 'post-operative' environmental conditions when examining rotational behavior. Special attention should be given when lesioned animals are individually housed and controls are group-housed, an experimental plan which could possibly, lead to an overestimation of differences in turnings.

In summary, individually housed rats carried out more rotational movements than group-housed animals when exposed to a novel environment. It was assumed that such behavior represented a further facet of the well known isolation-induced hyperreactivity toward a novel environment.

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Sexual behavior: influence of avoidance conditioning and of immediate punishment in male rats

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Summary. Mount, intromission and ejaculation latencies are reduced in male rats if they are previously subjected to an avoidance learning session or if the first 4 attempts to mount the female are immediately punished with an electrical shock.

It has been repeatedly observed that painful stimuli peripherally applied (back[1,2], tail[3]) as well as aversive stimulation of selected brain areas[4] pace and accelerate copulatory performance of sexually experienced male rats in the presence of receptive females, or pace copulatory behavior in virgin male rats[5].

We here report the results of a study of the effects of reputedly stressful or frustrating experimental models, such as active avoidance conditioning and immediate punishment, on sexual performance in adult male rats.

Materials and methods. 3-month-old male Wistar rats (220–250 g) were used. They were housed 5 per cage with food and water continuously available in a temperature-controlled colony room (22±0.2 °C; 60% relative humidity) with a 12-h light-dark cycle, with lights-off at 06.00 h. Starting after 1 week of adaptation to the laboratory, all subjects were tested for spontaneous sexual behavior. Tests were conducted 3 h after lights off under a red light. After a brief adaptation period in a semicircular glass mating arena, a stimulus female was presented to the male. (Ovariectomized females had been brought into estrous by administration of a single injection of 15 µg of estradiol benzoate, followed 48 h later by an injection of 1 mg of progesterone).

The following behavioral parameters were recorded: mount-mount with pelvic thrusting; intromission-mount with vaginal penetration; ejaculation-mount with intromission and a final prolonged thrust, slow dismounting and genital grooming; mount latency and intromission latency-period of time to the first mount and intromission, respectively; ejaculation latency-period of time from the first intromission to the ejaculation; postejaculatory interval-time from ejaculation to the first intromission of a new series.

The test was ended if the mount or intromission latency was > 15 min, if the ejaculation latency was > 30 min or if postejaculatory interval was > 15 min.

Only those males satisfying these criteria in at least the last 2 out of 5 preliminary weekly tests were selected for our study and randomly assigned to 2 groups of 12. The rats in the first group were trained for active avoidance conditioning. Shuttle boxes divided into 2 equal communicating compartments were used. The conditioned stimulus was the sound of a buzzer; if the rat did not cross the passage between the compartments within 5 sec, the unconditioned stimulus (an electrical shock of 25 V, 1.8 mA) was delivered through the grid floor of the box. 10 consecutive trials at 40-sec intervals were performed daily (from 08.00 to

Influence of avoidance conditioning and of immediate punishment on male sexual behavior, in rats (groups of 12 animals)

Treatment	Test No.	Mount latency (sec)	No. mounts	Intromission latency (sec)	No. intromissions	Ejaculation latency (sec)	Post-ejaculation interval (sec)
Active avoidance conditioning	4th + 5th[a]	14.71 ± 4.02	6.01 ± 1.12	58.17 ± 17.84	10.04 ± 1.13	538.96 ± 53.79	442.04 ± 24.02
	6th[b]	33.08 ± 17.13	2.91 ± 0.87	39.50 ± 17.02	9.67 ± 1.02	352.92 ± 73.68[c]	403.67 ± 26.29
	7th[b]	9.33 ± 4.49	5.17 ± 1.47	17.58 ± 6.66[c]	10.92 ± 1.14	440.83 ± 98.48	462.42 ± 16.70
	8th[b]	2.75 ± 0.72[e]	5.91 ± 1.72	14.50 ± 8.72[d]	11.67 ± 1.05	340.75 ± 38.31[d]	458.67 ± 29.71
Immediate punishment	4th + 5th[a]	6.87 ± 1.39	8.87 ± 3.97	24.00 ± 13.43	9.79 ± 1.33	430.08 ± 81.84	389.83 ± 25.41
	6th[b]	12.58 ± 4.37	4.83 ± 1.27[c]	21.58 ± 5.63	7.25 ± 1.48[c]	260.17 ± 56.42	438.92 ± 49.41
	7th[b]	1.83 ± 0.24[d]	5.41 ± 2.41	7.75 ± 3.16[c]	5.75 ± 1.28[d]	177.33 ± 44.52[d]	378.25 ± 22.55
	8th[b]	2.58 ± 0.42[d]	5.17 ± 1.85	18.36 ± 10.31	6.08 ± 0.97[d]	186.25 ± 36.74[d]	353.83 ± 30.19

Values reported here are means ± SE, but for the statistical analysis they were processed by the Mann-Whitney U-test. [a] Means of the values recorded in the last 2 out of 5 preliminary tests. [b] Experimental tests, i.e. tests performed during avoidance conditioning, or with immediate punishment of the first 4 mount attempts. [c] $p < 0.05$ (vs 4th + 5th tests values); [d] $p < 0.01$ (vs 4th + 5th tests values); [e] $p < 0.001$ (vs 4th + 5th tests values).

12.00 h) for 12 consecutive days, and on the 4th, 8th and 12th day of conditioning the rats were tested for sexual behavior immediately after the avoidance conditioning session.

The rats in the 2nd group were submitted to 3 tests for sexual behavior at 4-day intervals, the first 4 attempts to mount the female being punished with an electrical shock (25 V, 1.8 mA) delivered through the grid floor of the box (punishment also involving the female): so in these rats the parameters of sexual behavior were recorded starting after the 4th mount attempt.

Results and discussion. As shown in the table, both the stress of active avoidance training and that of immediate punishment of the first 4 attempts to mount the female reduced mount, intromission and ejaculation latencies. On the other hand, as would be expected[6–8], in a control group of rats tested in parallel the parameters of sexual behavior kept roughly stable from the 4th to the 8th test.

In the case of active avoidance conditioning it is undoubtly a matter of stimulation of copulatory performance, because mount, intromission and ejaculation latencies are reduced, while the number of intromissions needed to achieve ejaculation is not, nor is the post-ejaculatory interval prolonged.

In the case of immediate punishment, the marked reduction of the ejaculation latency, which is shorter by more than 50% in 7th and 8th tests than in 4th and 5th tests, is accompanied by an equally clear-cut reduction in the number of intromissions, and this might perhaps be interpreted as an equivalent of ejaculatio praecox[9]: but, in our view, the fact that mount latency too is definitely reduced and that the post-ejaculatory interval either remains unchanged or tends to shorten enables these data also to be interpreted as indicative of improved copulatory performance.

Our results are similar to those obtained by others with painful peripheral stimuli or with aversive stimulation of selected brain areas[1–5].

Our experimental design was quite different however, because, in the first place, rats were put together with stimulus females immediately after active avoidance training, while rats which had satisfied the learning criterion, thus avoiding shocks, also showed improved copulatory performance; and in the second place, rats were punished at the very moment they attempted to mount, mounting thus being immediately interrupted. Still, the possibility cannot be ruled out that in the first case the active avoidance training might have had an arousing effect, while interpretation of the results obtained with immediate punishment is more difficult. A role might be played by an increase in dopaminergic tone, as is the case of intermale aggression induced in rats by electric shocks[10]: it is known that brain dopamine stimulates male sexual behavior[11]. Copulatory performance is influenced by a number of extragonadal factors[12–20]: in humans it is adversely affected by seriously stressful situations[21,22] or by conditions leading to neuroticism, anxiety and depression[23,24]; and also in monkeys and in other species it depends greatly on environmental factors, such as rank in the social group[19], defeats by other males[19], social deprivation[25], etc.

Moreover, some data can be found in the literature on the effects of exposure to chronic psychogenic or somatic stress on testicular function in both animals and man. Indeed, it has been reported that surgery, immobilization or crowding induce a decrease in plasma testosterone levels in animals[19, 26–30]. In humans, major surgery, combat training, and intensive exercise in fear-evoking situations are also associated with a reduction in testosterone levels[22,31–34]. However, many of the above results[21–34] have been obtained with chronic stress, or in experimental conditions of chronic frustration or social humiliation, or with particularly stressful procedures (surgery, prolonged exposure to cold or immobilization, etc.) quite unlike our experimental models. In conclusion, the present results would seem to indicate that, in rats, male sexual performance is improved by the concomitance of mild stress or situations of conflict.

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Editorial postscript to 'Contemporary aspects of evolution' (Experientia *39* (1983) 805–844)

Evolution has come to be a central theme in biology, and science in general, and is destined to remain so for a long time. Every new aspect – from the genetic code to social complexity – immediately attracts attention. The flow of Charles Darwin Centennial Commenoratives suggests that the more we find out about biological mechanisms, the more difficult it becomes to formulate an integrated hypothesis of evolution.

There is some confusion about the meaning of Darwin's theory of evolution, confusion to which Darwin himself contributed in no small manner. Having already established with others the principles of evolution (Darwin doing so, of course, with his own masterly and definitive set of arguments), he concentrated on the *mechanism* of evolution and indeed seems to have considered his 'natural selection' hypothesis as the more important contribution. Not many biologists nowadays doubt that the basic tenets of his hypothesis, variation and selection, remain valid in principle. But the mechanisms involved are infinitely more complex than could have been foreseen in his time.

We were pleased to present, in the August 1983 issue of EXPERIENTIA, just a few interesting examples, and it is encouraging to see that some discussion in the form of letters to the editor has ensued.

H. Gloor, Geneva

Letter: Comments to the 'Introduction' and the 'Conclusion' of the reviews on 'Contemporary aspects of evolution' (Experientia 39/8, August 1983).

J.M. Smith's remarks on the article 'Complex-irreversibility and evolution' which read as follows: 'That the bridge from physics to biology is still difficult to cross is illustrated by Walker's article. Thus, I find myself in agreement with much of what she says in the first part of her article which is mainly concerned with physical principles, and yet I disagree with almost everything she later says on evolution' imply that the author of this article is believed to be a physicist. There is no doubt about this conviction in C. Petit's 'Conclusion', where she writes: 'The integration of the theory (of evolution) with the laws of physics is, however, not possible yet and Walker's attempt results in several conclusions which cannot be accepted by a biologist'.

As a matter of fact, the author of the article in question majored in Zoology at the University of Zürich (Ph.D. with Prof. E. Hadorn) and has worked as an invertebrate zoologist ever since. Incidentally, she has also lectured on the theory of evolution since 1970 (Imperial College London, Universities of Zürich and Geneva, Post-Graduate School of INPA Manaus).

The essential correctness of the physical views expressed is largely due to the generous help of theoretical physicists (M. Delbrück, and also my colleagues from Imperial College, mainly R.M. Williams and T.W.B. Kibble). Thus it might be fairer to concede that the bridge from biology to physics was crossed rather successfully. The bridge from the old synthesis of the fifties to renewed questioning seems to be more difficult to cross, and special acknowledgments are due to Experientia for opening up such new paths.

In view of the overwhelming volume of facts and figures that have accumulated in recent biology, I am of the opinion that attempts toward a synthetic theory between physics and biology are long overdue. The theoretical physicists of five to eight decades ago arrived at spectacularly successful models on the basis of a comparatively slender body of factual data. But, then, theoretical physics has always been a noble profession, whereas theoretical biophysics has, as yet, not even acquired academic legitimacy.

It is hoped that the article will stimulate discussion along new lines and possibly stimulate arguments over the points in question rather than merely provoke statements of categorical disagreement.

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When I wrote: 'The integration of the theory (of evolution) with the laws of physics is, however, not possible yet', I was not thinking in terms of a hierarchy among sciences. Physics can be helpful to the theory of evolution on two levels: while punctual applications have facilitated the solution of many important problems, the globalist, probabilist approach is valuable because of its rigor. But the construction of global models comes up against serious problems – such as our ignorance regarding the role of regulation genes or genic pool integration mechanisms. In this sense, I do not believe that synthesis is possible yet.

C. Petit, Paris