Individual housing of rats causes divergent changes in spontaneous and reactive activity

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Summary. Individually- and group-housed rats were compared in an animal activity meter, after several periods of different housing. Individually-housed animals showed a decreased spontaneous activity which could only be observed when the initial activity in response to the new environment had declined. It is concluded that the well-known phenomenon of isolation-induced hyperactivity is not due to an elevated spontaneous activity but to a hyper-reactivity.

It is known that, in animals, behaviour is not only determined by the genotype but is also influenced by living conditions. Differences in the environment, therefore, have severe and manifold consequences for an animal.

In rodents, rearing in individual housing causes behavioural, neurochemical and even anatomical alterations in comparison to rearing in the usual group housing[1-8].

As reported by several groups[1-3] and recently confirmed by our own results[9], individual housing of rats for a long period induces, amongst other behavioural effects, locomotor hyperactivity, this being the most prominent change. In all these studies locomotor activity was determined during relatively short periods of exposure to an open-field. Activity in single open-field trials gives information about activity in response to the new environment. Possible differences in spontaneous activity between individually- and group-housed animals are masked in this kind of experiment.

Recording activity with a relatively simple animal activity meter has the disadvantage of not being able to differentiate between individual behavioural parameters such as rearing, ambulation or locomotor complexity, as is possible during manually recorded open-field tests. However, they enable spontaneous activity over longer periods to be measured.

In the present study, activity was measured in rats which had either been individually-housed, or kept in groups of 3, for varying periods of time. Recordings made with an animal activity meter over long periods of time provided information on reactive and spontaneous activity. Additionally, the diurnal rhythm in the activity of differently housed rats was compared.

Methods. The activity of male rats (stock Füllinsdorf, originally a Wistar strain) was measured using 6 photoelectric detectors in an animal activity meter (constructed and made available by Sandoz Ltd, Basle). The method used is based upon that of Dews[13]. Individually-housed rats, which had been separated from their mother and siblings on the 19th day post partum (kept in macrolon cages 26×20×14 cm), and social rats, reared in groups of 3 (cages 42×26×14 cm), were transferred to the activity meter 1 h before recording began. The activity of 2 social and 2 isolated animals, each kept in a macrolon cage (42×26×14 cm) containing a thin layer of sawdust, could be registered simultaneously. The 4 cages were separated by thick paper to prevent the animals having visual contact. All environmental conditions were similar to those the animals had been familiar with since birth (room temperature 25 °C; reversed light and dark cycle with light on from 21.30 h to 09.30 h). The rats continued to have free access to food (Nafag) and water during the activity meter recordings.

Activity was recorded for 84 h (4 dark and 3 light phases). Interruptions of the 6 photoelectric beams were accumulated over successive periods, starting with the onset of the 1st dark phase.

At the time of these experiments, the rats were in age groups of 8, 10, 12 and 15 weeks (corresponding to a period of isolation of 5, 7, 9 and 12 weeks), with a maximum deviation in age of 5 days for each age group.

Results. Male rats individually-housed for 9 weeks showed an activity of 29,877± 1964 light beam interruptions over a period of 84 h. Age-matched, group-housed animals were significantly more active, having an activity of 34,556± 1096 counts over the same period ($p < 0.025$; mean ± SD; $n = 6$ for each group; Student's t-test). In figure 1 activity for consecutive 3-h periods is shown for animals reared under the different conditions. During the 1st 24 h no significant difference in activity was detected, the differently reared animals showing similar activity during the 1st dark phase. In later periods, individually-housed rats were always less active than group-housed controls. Taking into account that locomotion during the first 3-h periods is not basal activity, but a superimposition of additional activity (induced in reaction to the novelty of the test environment) onto spontaneous activity, measurements of basal spontaneous activity should be started only after a time of adaptation of about 1 day.

As regards spontaneous activity (between the 25th and 84th h), isolated rats were less active than group-housed controls not only during the dark phase but also during the light phase. The reduced activity of isolated rats seemed to be more pronounced in the dark phase (− 17%) than in the light phase (− 12%).

As can be seen in figure 1, there is no dramatic difference in the periodicity of the diurnal variation in activity between the differently reared animals.

Furthermore (figure 2), it can be seen that the stability of the diurnal rhythm was not influenced by the different housing conditions, as indicated by the parallel relative decrease of night activity and the parallel slight increase of light phase activity. These slight differences in the stability of the diurnal rhythm were probably due to experimental conditions; the pale light beams necessary for the photocell detectors to measure activity prevent absolute darkness between 09.30 h and 21.30 h and may therefore negatively influence the stability of the rhythm.

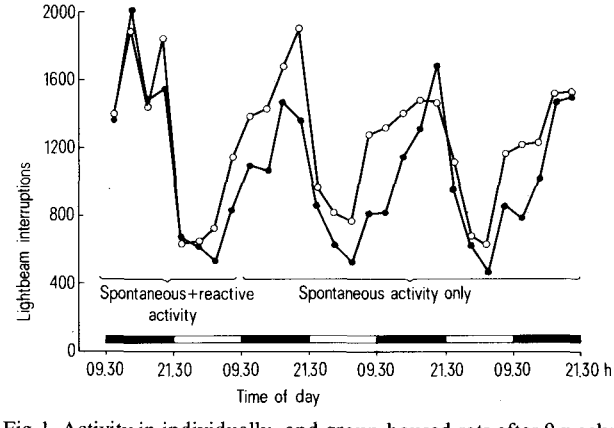

Fig. 1. Activity in individually- and group-housed rats after 9 weeks of different housing. Activity (lightbeam interruptions) was recorded during an 84-h period. Each point is the mean of 3 h activity for 6 animals. ● individually-housed rats, ○ group-housed controls.

In a further experiment, spontaneous activity was measured (these recordings were started after 24 h of adaptation) after different periods of isolation (figure 3). Similar results to those obtained after 9 weeks of isolation were obtained after both 5 and 7 weeks of different housing (corresponding to ages of 8 and 10 weeks); significant differences between isolated animals and controls could be observed. After 12 weeks of isolation, a reduction in activity was also found in individually-housed rats (but this was not significant).

Analysis of variance (5, 7, 9 and 12 weeks values) revealed an overall difference in activity between individually- and group-housed rats ($F = 11.4$, $p < 0.005$) but no influence on this effect due to the duration of different housing conditions ($F = 1.1$, not significant).

Discussion. Comparison of the activity of individually- and group-housed rats, measured by means of an animal activity meter, revealed differences in both spontaneous and reactive activity. Individually-housed rats showed less spontaneous activity than group-housed animals (figure 1, between the 25th and 84th h). The opposite finding was made for reactive activity: in comparison with the activity during the 2nd dark phase, assuming this represents true spontaneous activity, untouched by any response to the novelty, and taking this value as 100%, it can be seen (figure 2) that the activity during the first dark phase was about 25% higher in individually-housed rats. In contrast, group-housed animals showed a small difference (3%) between the 2 values. This is taken as an indication for a higher reactive activity in isolated rats than in group-housed controls.

The higher reactivity of isolated rats under these experimental conditions agrees with results obtained in open-field tests. In such experiments, individually-housed rats showed increased locomotion for at least 60 min (longer trials were not carried out).

Similar discrepancies between spontaneous and reactive activity were reported by Syme[10], in that individually-housed female rats were more active than group-housed controls in an open-field test but showed equal activity on an activity platform.

It may be surprising that reactive activity persists for more than 12 h, masking a subsequently observable difference in spontaneous activity during the 1st day of the experiment. This could be one reason why Benton and Brain[11] could not see any difference in the activity of isolated, dominant and subordinate mice (recordings were only made for 24 h). Very recently, del Pozo[12] reported elevated activity in isolated mice compared with group-housed controls, but these experiments too lasted for only 24 h and so it is questionable whether spontaneous or reactive activity was described.

The results presented here warn against misleading interpretations of spontaneous activity in experiments conducted with the aid of animal activity meters. Measurements over a period of less than 1 day seem to be severely influenced by reactive activity and have little value for the interpretation of spontaneous activity. At least, they should be treated cautiously. Recordings after 24 h of adaptation to the experimental conditions are more informative.

The fact that only 5 weeks of individual housing is sufficient to demonstrate different spontaneous activity, compared with group-housed controls, is again in full agreement with our own open-field data. Here it was shown that an equal period of isolation was sufficient to produce significant elevations in locomotor activity. In those experiments too, as reported here for spontaneous activity, the effect, once manifested, remained more or less stable even after longer periods of isolation (up to 15 weeks).

To summarize the present results, it may be concluded that the hyperactivity induced by individual housing in rats - a well-known phenomenon - is an indication of an excessive hyper-reactivity to a novel environment and is not due to elevated spontaneous activity.

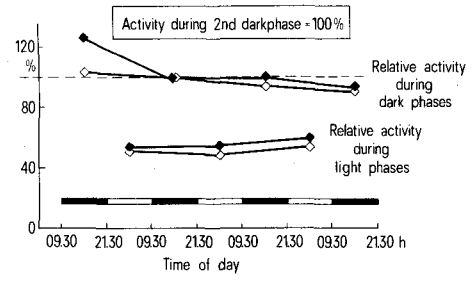

Fig. 2. Relative activity of individually- and group-housed rats, expressed as a percentage of the activity shown during the 2nd dark phase. Motility during the 2nd dark phase is assumed to represent only spontaneous activity (uninfluenced by any reactive activity to the new environment). Each point is the mean of 12-h activity for 6 animals ■ individually-housed rats, □ group-housed controls.

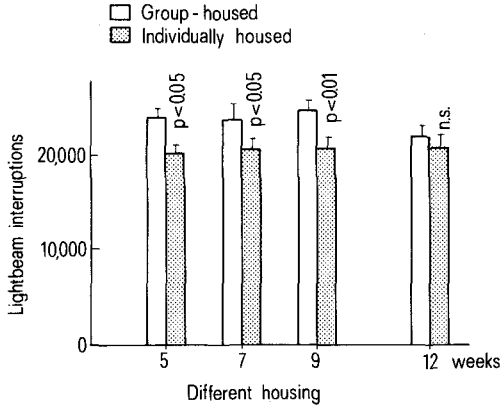

Fig. 3. Spontaneous activity after various periods of different housing. Recording was started after 24 h of adaptation to the new environment (activity meter) and then lasted 60 h (starting the experiment with the beginning of the dark phase). Values (mean ± SD) for individually- and group-housed rats ($n = 6$ for each group and each point of time) were compared by Student's t-test.

1 J. Garzon, J. Fuentes and J. Del Rio, Eur. J. Pharmac. *59*, 293 (1979).
2 B.J. Sahakian, T.W. Robbins, M.J. Morgan and S.D. Iversen, Brain Res. *84*, 195 (1975).
3 M. Weinstock and Z. Speiser, Psychopharmacologia *30*, 241 (1973).
4 M. Weinstock, Z. Speiser and R. Askenazi, Psychopharmacology *56*, 205 (1978).
5 N. Thoa, Y. Tizabi and D. Jacobowitz, Brain Res. *131*, 259 (1977).
6 F. De Feudis, Gen. Pharmac. *10*, 281 (1979).
7 A. Globus, M. Rosenzweig, E. Bennett and M. Diamond, J. comp. physiol. Psychol. *82*, 175 (1973).
8 O. Jørgensen, Neurochem. Res. *4*, 175 (1979).
9 C. Gentsch, M. Lichtsteiner, K. Kräuchi and H. Feer, unpublished manuscript (1980).
10 L.A. Syme, Anim. Learn. Behav. *1*, 161 (1973).
11 D. Benton and P.F. Brain, Behav. Processes *4*, 211 (1979).
12 F. del Pozo, F.V. De Feudis and J.M. Jimenez, Experientia *34*, 1302 (1980).
13 P.B. Dews, Br. J. Pharmac. Chemother. *8*, 46 (1953).