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Social and non-social open field behaviour of rats under light and noise stimulation

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Abstract

In two experiments, male rats were observed in pairs under different environmental stimulations in an open field. In Experiment 1, white noise of 85 dB(A) reduced social activities and increased defecation compared to 75 dB(A) and 65 dB(A). In Experiment 2, the illumination of the open field was varied in addition to a variation of the noise intensity. Again, 85 dB(A) as compared to 50 dB(A) reduced social activities and increased defecation, but also led to changes in non-social behaviours such as sniffing, grooming, and rearing. In contrast, 400 lx did not differ substantially in its effects from 40 lx in any of the observed behavioural categories. Altogether, the behaviour pattern under 85 dB(A) white noise cannot satisfactorily be explained only by increased anxiety or fear. Alternative explanations are discussed.

Key words: Social activity; Stress; Light stimulation; Noise stimulation; Environment; Open field behaviour; Emotionality; Rat

Introduction

When two male laboratory rats are placed in an open field or a similar test arena they show a variety of social activities like sniffing, grooming, crawling and kicking each other. The amount and the patterning of social behaviour can be influenced by various social and environmental factors like social isolation (Latané et al., 1970, 1972; Latané and Steele,

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1975), novelty and/or illumination of the test environment (Eckman et al., 1969; File and Hyde, 1978). A reduction of social behaviour under aversive environmental stimulation has been explained by emotional alterations involving fear or exploration which compete with the tendency to engage in social activities (Eckman et al., 1969; Latané and Walton, 1972). So, active social interaction of a pair of male rats is used as an indicator of the animals' anxiety in the social interaction test (SIT; File, 1980, 1983; File and Hyde, 1978). In this paradigm, novelty and a bright illumination, often regarded as innate fear stimuli, lead to a reduction of active social behaviour. In our experiments we investigated whether another environmental stimulus, noise, would lead to comparable effects on the social behaviour of rats.

Experiment 1

While the effects of bright light on social behaviour of rats have been examined in several studies (File, 1980; File and Hyde 1978; Gardner and Guy 1984), social behaviour under noise has not yet been investigated. Experiment 1 thus examined the effects of different intensities of continuous white noise on social activities. In addition, defecation and locomotor activity were recorded to estimate non-social noise effects.

Method

Subjects and apparatus

Subjects were 30 experimentally naive, male Sprague-Dawley rats (Han:SPRD, Zentralinstitut für Versuchstierzucht, Hannover, FRG), about 8 to 10 weeks old and weighing 250–280 g upon arrival. The rats were individually housed under controlled light (40 lx, 6:00 am – 5:00 pm) and temperature (22 ± 1°C) conditions with ad lib food and water. Air conditioning and other equipment in the housing room provided a background noise of about 50 dB(A). Experimental procedures were carried out between 7:00 am and 1:00 pm.

The test arena consisted of a wooden enclosure (60 cm × 60 cm × 40 cm). Continuous noise generated by a white noise generator was presented by two speakers mounted 150 cm above the floor of the open field. An analysis of the frequency characteristics of the speakers revealed a frequency spectrum of 100–18 000 Hz. Above 1000 Hz the sound pressure level diminished with about 15 dB/octave. Illumination was provided by two incandescent light bulbs 200 W each, 60 cm apart, and 115 cm over the floor. A white translucent screen mounted at a height of 100 cm ensured a uniform illumination of the open field and hid the loudspeakers and the videocamera.

Procedure

After one week of acclimatization, and before being tested, all rats were individually handled on 5 consecutive days and in addition placed in the open field on the last four days in order to habituate them to the test arena. These pretests involved being placed in the open field for 5 min under noise and light conditions comparable to those in the housing room, i.e. 50 dB(A) white noise and 40 lx. To be able to distinguish the two animals of a test pair later on in the behavioural analysis, half of the rats were marked with a thin black line at the tail on each pretest day, while the other half were sham-marked with a colourless pen. After the pretest days the rats were randomly assigned to one of three experimental treatments, and within each treatment group, pairs of rats were randomly arranged.

On the test day, about 24 h after the last pretest session, the two rats constituting a pair were simultaneously placed in the center of the open field. All rats were tested with the illumination already used in the pretest sessions. Five pairs were tested with 65 dB(A) white noise, 5 pairs with 75 dB(A), and 5 pairs with 85 dB(A). After each 10 min test session the open field was wiped clean. All sessions were videotaped for later analysis.

During replay, social behaviour was classified binary as present or not present, and time spent in social activity was recorded for each pair of rats for the 10 min by two trained observers being unaware of the experimental condition. Social behaviour was coded as present for a rat pair when the observable activity of either of the two rats or of both was evidently directed towards the conspecific. Body contact was neither a necessary nor a sufficient condition for this coding. A detailed description of the social behaviours subsumed under this measure is provided in Table 2.

To determine ambulation, the videomonitor was covered with a clear plastic sheet marked with black horizontal and vertical lines which divided the open field into 16 squares of the same size. A score for ambulation was registered when an animal crossed a line with all four paws resulting in the number of squares traversed. For each pair of rats, the sum of the ambulation scores was calculated.

Defecation was determined by the total number of boli for each pair after each session.

Results and Discussion

Values for ambulation, defecation, and social activities are shown for each experimental group in Table 1. One-way ANOVA revealed a significant effect for defecation, $F(2, 12) = 6.2$, $P < 0.05$, and social behaviour, $F(2, 12) = 9.01$, $P < 0.01$. Subsequent Scheffé-Tests showed higher defecation for the rats tested under 85 dB(A) as compared to

TABLE 1

Ambulation (number of crossings), defecation (number of boli) and time spent in social activities (s) under different noise conditions during the 10 min open field session in Experiment 1 ($n = 5$ pairs for each group)

	65 dB(A)	75 dB(A)	85 dB(A)
Ambulation			
M	556.6	515.0	437.6
S.D.	46.6	66.7	92.8
Defecation			
M	3.0	4.6	11.6
S.D.	2.6	4.2	5.2
Social behaviour			
M	413.2	383.8	319.9
S.D.	34.0	15.4	48.9

NB: Values for ambulation and defecation represent sum scores for tested pairs of rats. Values for social behaviour represent time spent in social activities coded for each pair.

the 75 dB(A) group, $P < 0.05$, and the 65 dB(A) group, $P < 0.05$. The difference between the 65 dB(A) and 75 dB(A) groups did not reach significance level.

Under 85 dB(A) pairs of rats spent less time in social activities than under 75 dB(A), $P < 0.05$, and 65 dB(A), $P < 0.05$. The latter two groups did not differ significantly. Animals tended to ambulate less the more intense the white noise, but this effect is not significant ($F(2, 12) = 3.59$, $0.05 < P < 0.10$).

In this experiment, even with a small number of cases, strong effects of white noise with an intensity of 85 dB(A) as compared to 65 dB(A) were found on defecation and social activity, while the effects on ambulation were less pronounced. The effects of the different noise levels on defecation are comparable with results of experiments where defecation has been measured in individually tested rats under different noise intensities (Archer, 1973), whereas the reduced social activity parallels the effects of a brightly lit and unfamiliar environment. The increased defecation suggests heightened emotional reactivity which may be incompatible with social activity in this situation.

Experiment 2

This experiment was conducted to investigate the effects of white noise as found in Experiment 1 in more detail and therefore involved a description of several social and non-social behaviours. It also compared the effects of intense noise with those of bright light and examined the effects of a combination of the two stimuli.

Method

Subjects and apparatus

Experimental Ss were 64 naive male Sprague-Dawley rats obtained from the same breeding center as in the first experiment. They were 8–10 weeks old, weighed 200–250 g on arrival, and were housed under the same conditions as described in Experiment 1. The open field and the devices were also the same as above.

Procedure

Within a 2 × 2 factorial design with white noise and illumination as the independent factors, one half of the rats was tested under 50 dB(A) white noise, the other half was tested under 85 dB(A), the noise level that was most effective in Experiment 1. One half from each noise group was placed in the open field with the illumination intensity already used in Experiment 1, 40 lx, while the other half was tested with 400 lx. Rats were handled and pretested as in the first experiment.

In addition to ambulation and defecation, various non-social and social behavioural patterns were registered. Table 2 lists the used behaviour categories and short operational definitions, based on descriptions in the literature (Barnett, 1975; Grant, 1963; Grant and Mackintosh, 1963; Scott, 1966, 1969; Timmermans, 1978; Welker, 1964). Three out of the seven categories of social behaviour consisted of behaviours which can be characterized as agonistic. As some of these categories were relatively infrequent, a sum score was computed to get a more reliable measure of agonistic behaviour.

During the replay of the taped test sessions, the behaviour of each rat was continously coded by two trained observers not informed about the experimental condition. With each

TABLE 2

Operational definitions of the behaviours recorded for each subject in Experiment 2. Behaviours are measured as duration(s) except for defecation (number of boli) and ambulation (number of crossings)

Non-social behaviour	
Defecation	Fecal boluses
Ambulation	Crossing a line with all four paws
Sniffing	Movements of vibrissae, nose and head without locomotion and without social contact
Rearing	Raising of body to hind limbs into an upright position without social contact
Grooming	Licking of own body and/or rubbing of the own face or fur with the front paws
Social behaviour	
Sniffing the conspecific	Movements of vibrissae, nose and head toward the conspecific
Following	Approaching and walking behind the conspecific
Crawling under/over	Rat moves under or over the other rat; also included is putting the paws on the back of the conspecific
Fighting	Rapid behavioural sequences including one of the following elements: chassing, kicking (with nose or paws), pushing, biting or forcing the conspecific onto back
Boxing	Rat adopts an upright posture, 'face to face', and pats the conspecific with its forepaws
Grooming the conspecific	Licking and chewing the fur of the conspecific
Aggressive grooming	Vigorous grooming of the neck and shoulder of the conspecific; grooming rat is above the other

observed behavioural change the corresponding number key of a microcomputer key path was pressed by the observer. A BASIC-program computed the frequencies and durations of each coded behaviour. Results will be reported only for the sum scores for the total session. Only one animal from each pair was randomly chosen for statistical analysis. Therefore, the number of rats in each experimental group equals 8 for all analyses reported in the following section.

In addition, for a comparison between the two experiments we included the score for social activity observed in rat pairs as described in Experiment 1.

Results and Discussion

Non-social behaviour

Means and standard deviations for ambulation, defecation and the non-social behaviour categories are shown in Table 3.

TABLE 3

Non-social behaviours under different noise and light conditions during the 10 min open field session in Experiment 2 ($n = 8$ for each group)

	50 dB(A)		85 dB(A)	
	40 lx	400 lx	40 lx	400 lx
Ambulation				
M	266.6	259.8	229.0	239.3
S.D.	77.4	34.7	29.6	44.4
Defecation				
M	2.0	2.1	5.0	4.9
S.D.	2.1	3.1	1.5	3.1
Sniffing				
M	192.6	202.7	241.4	229.5
S.D.	47.2	42.1	33.5	34.7
Rearing				
M	53.6	56.9	90.9	69.2
S.D.	17.5	23.1	18.7	18.5
Grooming				
M	19.9	20.4	34.3	31.7
S.D.	12.0	8.1	25.8	20.9

NB: Values for ambulation and defecation represent counts while values for sniffing, rearing and grooming are measured as duration(s).

The 2 × 2 ANOVA for defecation revealed a main effect for noise, $F(1, 28) = 10.08$, $p < 0.01$. As indicated by the means in Table 3, white noise with an intensity of 85 dB(A) significantly increased defecation as compared to 50 dB(A). No significant effects could be detected for the ambulation scores.

As can be seen in Fig. 1, the introduction of a conspecific results in an increase in ambulation and in a decrease in defecation.

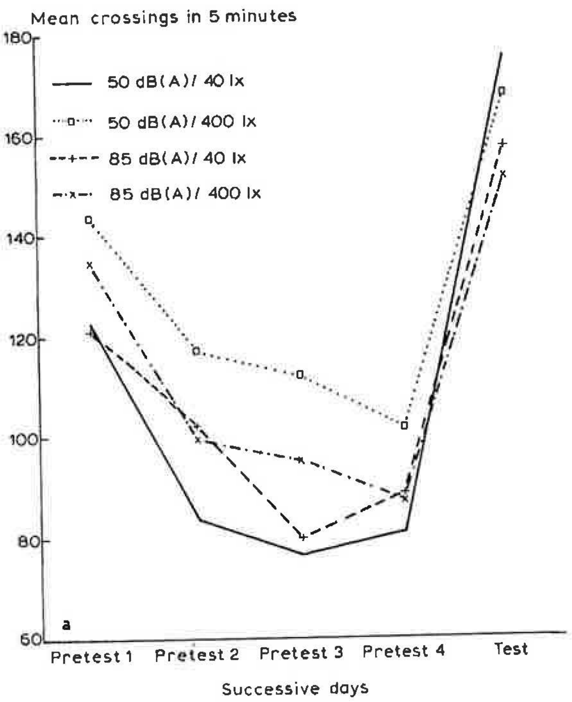
For the remaining non-social behaviours, 2 × 2 ANOVAs again revealed significant main effects only for the noise factor indicating increased rearing, sniffing, and grooming with the intense noise level, $F(1, 28) = 12.85$, $P < 0.01$, $F(1, 28) = 7.23$, $P < 0.05$, and $F(1, 28) = 4.05$, $P < 0.05$ respectively, with none of all the other comparisons showing reliable differences.

Social behaviour

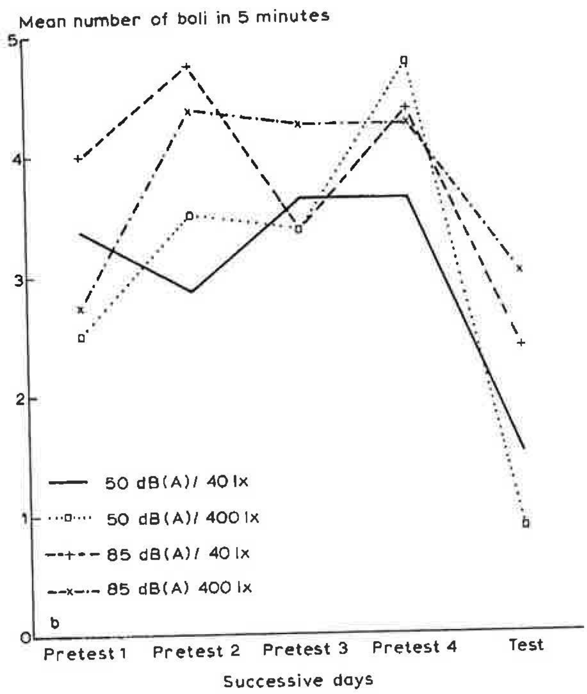
The mean time spent in social behaviour as measured by observation of rat pairs was significantly reduced by the more intense noise, $F(1, 28) = 34.04$, $P < 0.001$. Rat pairs engaged approximately two thirds of the test session in social behaviours under low noise conditions, but only half the time under the intense noise condition (cf. Fig. 2). Bright light had no significant effect, $F(1, 28) = 0.08$, and there was no interaction between noise and light, $F(1, 28) = 0.003$.

Fig. 1. Ambulation and defecation during 5 min in the open field on the pretest days and on the test day, on the latter as a function of noise and light intensity, in Experiment 2. NB: Because, in the pretests, the rats spent 5 min in the test arena, only the mean values of the first 5 min are represented for the test day.

Ambulation



Defecation



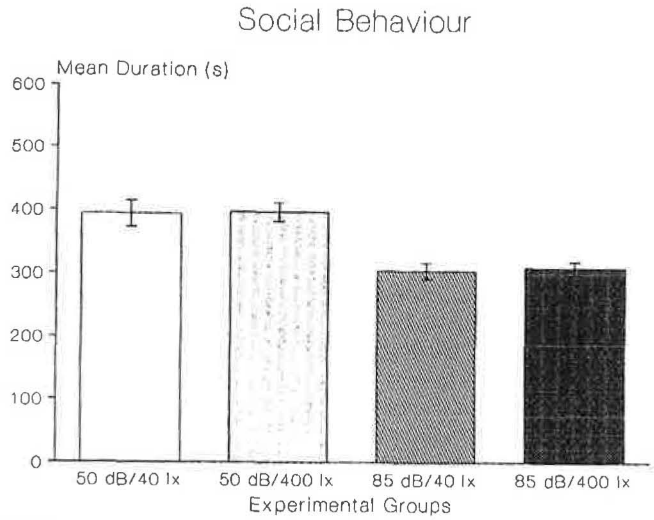


Fig. 2. Mean ($\pm$S.E.M.) duration of social behaviour(s) as observed in rat pairs as a function of noise and light intensity during the 10 min open field session in Experiment 2 ($n = 8$ pairs for each group).

The same pattern of results emerged for the summarized score from all categories of social behaviour observed in the individual rat (cf. Table 4), the second measure of overall social activity: white noise with an intensity of 85 dB(A) significantly reduced social behaviour, $F(1, 28) = 22.09$, $P < 0.01$. Mean durations of fighting, boxing, aggressive grooming and social grooming were reduced by the intense noise, $F(1, 28) = 4.40$, $P < 0.05$, $F(1, 28) = 8.08$, $P < 0.01$, $F(1, 28) = 6.30$, $P < 0.05$, $F(1, 28) = 11.42$, $P < 0.01$ respectively, whereas for none of the remaining categories of social behaviour ANOVA indicated significant differences. The time spent in each of the behavioural categories labelled agonistic (fighting, boxing, aggressive grooming) was very low under the 85 dB(A) noise condition (cf. Table 4). As was to be expected, the sum score for the amount of time spent in these behaviours is reduced by this noise intensity, $F(1, 28) = 6.23$, $P < 0.05$.

General Discussion

In general, white noise with an intensity of 85 dB(A) increased defecation and reduced social activities as compared to 65 dB(A) in Experiment 1 and 50 dB(A) in Experiment 2. In comparison to 50 dB(A), it led to changes in other behaviours as well. So, time spent sniffing, rearing, and grooming increased. The overall reduction in social activities mainly resulted from a decrease in social grooming as well as from a decrease in agonistic behaviours.

In contrast, we could not find any effects of bright light. One explanation could be that specific pre-experiences like very low light housing conditions may be necessary to induce reliable effects of intense light on social behaviour. In addition, the low light level during testing might have been already too high. Gardner and Guy (1984), for example, found a reduction of social activities under 400 lx as compared to a 5 lx control illumination. Furthermore, our rats were observed in a familiar open field, and familiarity of the test

TABLE 4

Duration of social behaviours(s) under different noise and light conditions during the 10 min open field session as observed in individual rats in Experiment 2 ($n = 8$ for each group)

	50 dB(A)		85 dB(A)	
	40 lx	400 lx	40 lx	400 lx
Sniffing the conspecific				
M	74.1	77.9	78.7	85.6
S.D.	35.8	18.1	23.0	18.1
Grooming the conspecific				
M	57.2	50.4	36.6	23.5
S.D.	32.1	19.0	10.4	8.8
Following				
M	22.3	19.3	18.9	9.9
S.D.	10.0	7.4	16.5	8.3
Crawling under/over				
M	10.4	12.5	9.0	12.6
S.D.	8.5	9.4	5.1	7.9
Fighting				
M	24.9	22.5	3.4	0.8
S.D.	53.9	21.3	4.8	1.9
Boxing				
M	8.1	7.0	1.7	1.7
S.D.	8.8	6.9	1.8	2.6
Aggressive grooming				
M	3.1	2.4	0.3	0.1
S.D.	4.9	2.9	0.6	0.4
Aggressive behaviours				
M	36.1	31.9	5.4	2.6
S.D.	61.9	27.2	5.1	4.1
Total social behaviour				
M	200.2	192.0	148.7	134.3
S.D.	43.6	15.6	40.6	23.0

NB: Aggressive behaviours represent the sum of time spent in fighting, boxing and aggressive grooming. Total social behaviour represents the sum of time spent in all social behavioural categories observed in the individual rat.

environment could be a modifying variable. The results reported by Thor et al. (1988) also point in this direction. They tested rats in the home cage environment with an even higher illumination level, as in the present experiment, and could not detect any marked effects on the behaviour directed towards juvenile conspecifics. Strain differences in light sensitivity may also be considered.

The findings of both our experiments clearly show that white noise with an intensity of 85 dB(A) as compared to 65 and 50 dB(A) leads to a marked reduction of the amount of time male rats engage in social interaction with a male conspecific during the 10 min of the encounter, whereby especially agonistic behaviours are reduced. This change in social behaviour under noise is accompanied by changes in other behaviours. First, defecation increases, an effect of noise which has been shown as well for rats tested alone in the open field (Archer, 1973). And, as the results of the first experiment show, defecation is as sensitive to increasing intensities of white noise as is social behaviour. Increased defecation has also been reported with increased illumination and unfamiliarity, and this effect has been considered as one indicator of increased arousal or even anxiety, besides increased freezing and "displacement activities" (File, 1980, 1981). Second, time spent sniffing and time spent rearing are increased by noise which can be interpreted as increased exploratory activity (Archer, 1973; Toates, 1980; Walsh and Cummins, 1976). Third, time spent grooming is increased as well, which may indicate heightened activation (Dunn, 1988). So, the reduction of social behaviour under noise does not reflect a similar reduction in other behavioural categories. On the contrary, rats under moderate noise are more engaged in non-social activities. For the 85 db(A) noise condition we therefore cannot conclude that the observed changes in social behaviour "are not so far explained by any changes in other competing behaviours such as exploration" (File, 1980, p. 223).

Of course it would be helpful to identify a unitary motivational state that may help to explain the effects of the intense noise level in our experiment. So, the changes in social activities and defecation may be interpreted as anxiety reactions, although the validity of the latter variable is still under discussion (Archer, 1973; Gray, 1987) and may be questionable especially in social situations (Weijers, 1993). As can be concluded from the results already mentioned, noise-induced exploration in the otherwise familiar environment would be a second candidate. Besides the conspecific, the white noise is another novel stimulus which has to be considered by the animal. The increase in the amount of time for both, non-social sniffing and rearing, indeed indicates that the rats' behaviour is directed specifically toward environmental stimuli other than the conspecific, i.e. the noise applicated from above the open field. However, with the intense noise level used in our second experiment it seems possible that both processes, exploration and anxiety, are involved (c.f. Russell, 1973).

Because effects of bright light as previously reported for the SIT were not confirmed, it was impossible to compare patterns of effects in order to differentiate the two stimuli with regard to their behavioural effects in a social situation. However, with the results obtained for noise it may be worthwhile to study, as is done in the SIT, the effects of differing classes of psychoactive drugs. If the effects of noise on social activities correspond to those from illumination and unfamiliarity as measured in the SIT, then anxiolytic drugs should be expected to be also effective in the noise situation, i.e. they should increase social interactive behaviour. This would lead to the conclusion that the reduced social activity under noise is mainly caused by systems involved in the regulation of emotional reactivity, hence broadening the concept of the SIT to another aversive stimulus. On the other hand, if anxiolytic drugs do not reliably change the behaviour pattern under noise, the involvement of some other mechanism has to be postulated.

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