Psychopharmacologia (Berl.) 10, 155-171 (1966).

Barbiturates, Lysergic Acid Diethylamide, and the Social Behaviour of Laboratory Rats

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Received December 28, 1965

Behaviour has a structure, and (as CHANCE has pointed out in a personal communication) behavioural effects of drugs can be better understood in the wider context of ethology (CHANCE and SILVERMAN, 1964). TINBERGEN (1963) described ethology as "the biology of behaviour", meaning that ethologists are interested not only in the description of a piece of behaviour and its causation or motivation in the individual, but also its function and origin, both in the individual and in the species. Drugs can be useful tools in unravelling the anatomy and physiology of behaviour, if one also remembers that the behaviour has an ontogeny, a taxonomy, and a survival value.

The elements composing the social behaviour of laboratory rats, *Rattus norvegicus*, have been analysed by E. C. GRANT, and the balance of this repertoire can be experimentally modified in various ways, notably by drugs. Thus chlorpromazine reduces behaviour (aggression, mating, etc.) involving approach to another rat, and increases flight away from him, leaving behaviour not oriented to another individual substantially unaffected (SILVERMAN, 1965 and 1966). In the present paper, the effects of amylobarbital, pentobarbital, and lysergic acid diethylamide on the social behaviour of rats will be described. These drugs appear to act in the opposite direction to chlorpromazine, in this situation.

Method

That the method is objective will become apparent from the results (cf. Discussion). It is described in detail elsewhere (SILVERMAN, 1965), but in outline was as follows. Isolating rats for a few days and then introducing one (the "partner") into the home cage of another concentrates their social behaviour into a short period of the experimenter's choice. Drug effects can be revealed by comparing six drug- and six saline-injected rats, meeting the same partners in a suitably counter-balanced order.

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Over 40 actions and postures have been recognised in the behaviour of rats (GRANT and MACKINTOSH, 1963), and these elements occur in statistically distinct sequences (GRANT, 1963). Some elements (e.g. *Retreat*, *Mount*, *Bite*), though not necessarily frequent themselves, permit such objective sequences to be labelled by their apparent function. Thus, *Retreat* is defined as "a directed movement away from" the other rat, and elements statistically associated with this are said to reveal Flight. Though few elements belong to one such group alone, they can be classified by the tendency which predominates.

The categories are named: Exploration of the physical environment; Investigation (exploration of the other rat) together with Mating; Aggression (including *Bite* when it does occur); Submission (Flight allowing rats to remain in close proximity); Escape (Flight away from the other rat); Maintenance (eating, self-grooming, etc.); and Residual (for elements of rare occurence or obscure motivation).

One observer watched injected animals, another the partners (but in test 5 they alternated). The observer spoke the codeword for each element on to a stereo tape-recorder as the animal performed it, averaging about 300 elements of all kinds for each rat in a ten-minute introduction. Tests 13, 22, and 26 were in two parts, with a week's interval (the procedure is described below for test 13).

Rats were males of an agouti strain (albino in test 6), bred in the laboratory, 10 to 12 weeks old at testing, and averaging about 260 g in weight. The diurnal lighting cycle had been reversed for at least two weeks before testing and the rats isolated one per cage for one.

Barbiturates were made up daily by adding distilled water to a weighed quantity of the powder, amylobarbital sodium at 2.5 to 10 mg/kg, pentobarbital sodium in doses of 2.5 and 5 mg/kg. Lysergic acid diethylamide (LSD) was diluted from ampoules and given in doses of 1 and 4 μg/kg. Controls received commercial "normal saline for injection". All injections were intraperitoneal in a volume of 1 ml/kg, and were given about half a minute before the partner was introduced.

Results were analysed by a series of χ^2 tests on the total numbers of each element shown by six rats given a drug and six given saline, meeting the same partners for 10 min each. For the first, the figures were cast in a table of $2 \times N$. N varies slightly, since some elements are not always frequent enough for separate treatment. The overall value of χ^2 is a crude measure of the total pattern effect of the drug, and the contribution of each element shows which elements have been individually significantly increased or reduced by the drug.

Interpreting a list of such altered elements for each experiment would prove tedious, so most results will be described in terms of the categories listed above. One χ^2 compares drug and saline on the total for

all elements included in each category (at 1 degree of freedom): since they share their main motivational factor, any drug effect on this would summate and show a significant effect on the category total. Secondly, since an excessive effect on a single element might be deceptive, the elements within each category are compared in a table of $2 \times n$ for their variability. The χ^2 value of drug effects on category totals and variability can be shown graphically on a histogram.

The χ^2 value is directly proportional to a percentage increase or decrease from the control level, except that it includes two corrections: 1. The χ^2 value corrects for the absolute value of the numbers to be compared (thus, a 25% difference from 100 matters more than a 25% difference from 10). One rat may show one element 50 times and another element not at all. 2. The χ^2 value also corrects for the "total activity", the total number of elements recorded for the drug-treated and control rats. (Thus, if the total activity of the former is 10% less than that of the controls, a 10% reduction in aggression gives a category χ^2 of zero.)

Similarly the partners' behaviour on meeting drug-injected rats can be compared with that to controls. Consistent effects on the partners (who have not received the drug) suggest that they perceive and react to the same behaviour as the observer records.

Results

The Table lists the experiments made by drug and by dose.

Amylobarbital sodium. Amylobarbital was first given in test 9 in doses of 2.5 and 10 mg/kg, after the usual seven days isolation.

Fig. 1 shows that:

Exploration of the cage was slightly increased by the small dose of the drug.

Investigation and Mating were reduced by the small dose but slightly increased by the large.

Aggression was greatly increased by both doses, quite uniformly and in the usual ritualised elements (*Bite* is rare).

Submission, the "social Flight", was slightly reduced.

Escape was considerably reduced, especially by the larger dose.

Maintenance was not affected uniformly: *Wash* was reduced and *Eat* tended to increase.

Residual elements were not affected.

The partners' behaviour reflected these effects: there was more Submission to rats given amylobarbital, and to the larger dose there was also more Escape and reduced Investigation and Mating.

In brief, there were marked and dose-responsive effects on behaviour oriented to the other animal (opposite to those of chlorpromazine, incidentally), while non-social behaviour was relatively unaffected.

Table

Test no.	Dose	Remarks (further explained in text)	Experimentals χ^2	df	Partners χ^2	df	
Amylobarbital sodium							
9	2.5 mg/kg		199.9	33	175.3	28	
9	10 mg/kg		237.0	33	189.8	29	
13/1	5 mg/kg	3 days isolation	151.3	34	35.4	26	*NS*
13/2	5 mg/kg	cf. controls in boxes	240.5	31	86.0	29	
		cf. controls in cages	152.1	34	106.5	28	
26/2	5 mg/kg	comparing by sex of partners	614.5	37	394.3	31	
		comparing to controls with female partners	202.5	37	82.8	25	
Pentobarbital sodium							
5	2.5 mg/kg		109.1	30	92.4	33	
6	2.5 mg/kg		69.9	29	53.2	26	$p < .01$
13/1	5 mg/kg	3 day isolation	125.8	34	59.8	27	
Lysergic acid diethylamide							
15	1 µg/kg		101.7	33	110.1	30	
15	4 µg/kg		102.5	34	90.2	29	
22/1	1 µg/kg	3 day isolation	77.2	32	28.6	32	*NS*
22/1	4 µg/kg	3 day isolation	117.0	29	40.3	32	$p < .05$
22/2	2 µg/kg	comparing by sex of partners	246.8	35	269.4	32	
		compared to controls with female partners	91.8	35	70.4	30	

List of experiments. The reference numbers give the order in which these tests and those described elsewere (SILVERMAN, 1966) were made. The table shows the value of the overall χ^2 for the 27—38 elements shown in each test by 6 drug-treated and 6 saline-injected rats, and the corresponding differences in the partners. Unless otherwise stated, preexperimental isolation was for 7 days, and all differences were significant at $p < .001$.

However, in some confirmatory tests the results were much less clear. This seems to have been because the prior isolation had been for seven days, a period chosen as inducing the maximum social behaviour on introduction. In these later tests, amylobarbital nearly always slightly increased the total activity (the total number of elements recorded), but the single element most consistently increased was *Tail-rattle*, which occurs between *Retreat* and *Approach* when tendencies involving both are highly aroused.

Increased Aggression and any rise in overall activity, could be accounted for as disinhibition following a reduction in Flight. Yet in

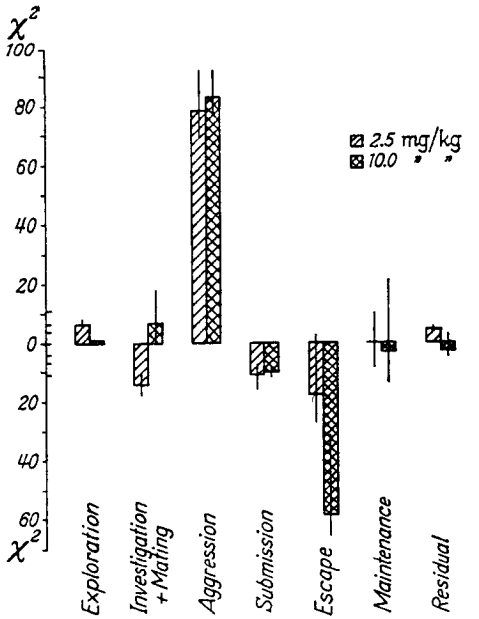

Fig. 1. Actions of amylobarbital sodium at 2.5 and 10 mg/kg, expressed as the χ^2 value of deviations from the control level. For each category, the rectangles represent the category χ^2 at one degree of freedom. The lines represent the variability χ^2 for the elements included in each category, and (reading from the left) are at 1, 5—8, 4—7, 2, 5—8, 3—7, and 1—2 degrees of freedom respectively. Elements sometimes occur too infrequently for independent inclusion in the variability χ^2, and have to be combined

tests where the controls were most active, Flight was not consistently reduced, and the increase was less often in Aggression than in the less specific *Tail-rattle*. A hypothesis was made, therefore, with the three connected points that:

i) amylobarbital caused an increase rather than a reduction,

ii) the increase was not in a specific tendency but in the extent of the response to any given stimulus, and

iii) the increase was limited, probably by the rat's rate of performance (since the observer has a higher rate of recognition and naming of the elements with mice). For some reason this limit had not been reached in the original test, leaving room for the drug effects.

These ideas were examined in test 13 in two ways. In the first, pre-experimental isolation was for three days only, and observation was "blind" insofar as the observers did not know whether a particular solution contained amylobarbital, pentobarbital (both at 5 mg/kg), or saline.

With shorter isolation, amylobarbital increased overall activity by 12% (from 1925 elements for the controls to 2152), with a change in pattern very similar to that of test 9. Fig. 2 shows that:

Exploration of the cage was unchanged overall, but was more active.

Mating (but, in fact, not Investigation) was increased.

Aggression was increased.

Flight was reduced, both Submission and Escape.

Maintenance and Residual elements were not altered.

In this test, the overall differences in the partners were not statistically significant, but there were hints that the drug indirectly increased partners' Flight. Pentobarbital is discussed below.

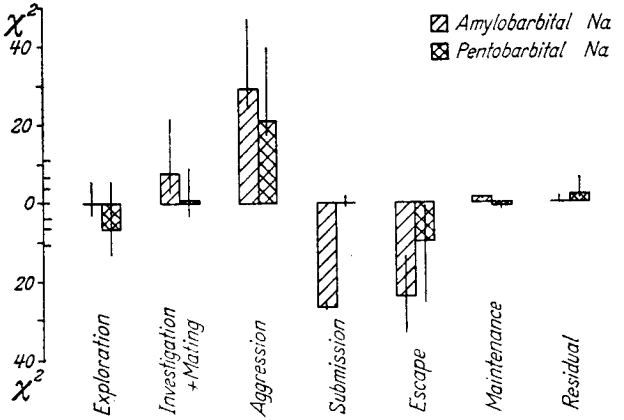

Fig. 2. Actions of amylobarbital and pentobarbital (5 mg/kg) in rats isolated 3 days only before introduction. Further explanation as in Fig. 1 and in text

The second test of the hypothesis utilised an unpublished observation by CHANCE that rats introduced in opaque boxes show very much less agonistic behaviour than in cages. The same animals were used as in test 13/1 but met different individual partners. Two rats from each injected set remained in their home cages for a further week as cage saline controls. The others were housed in boxes of galvanised iron sheet, but retained their accustomed sawdust covered tray; six became box saline controls, and six were given amylobarbital at 5 mg/kg. The partners remained in their home cages, and were introduced into the box or cage as required.

The effect of boxes on saline controls was to reduce their activity to 85% of that in cages, with a striking ($\chi^2 = 323.0$, $df = 32$) difference in behavioural pattern. Box controls showed very much less Aggression and Submission, relatively as well as absolutely, but more Escape, Investigation, Maintenance, and Exploration (including attempts to climb out of the box). Partners, in boxes solely during the introductions, showed similar but smaller effects. It is not known why the boxes had this influence.

Amylobarbital increased activity to 10% over the cage control level, and the pattern resembled the cage more than the box controls ($\chi^2 =$

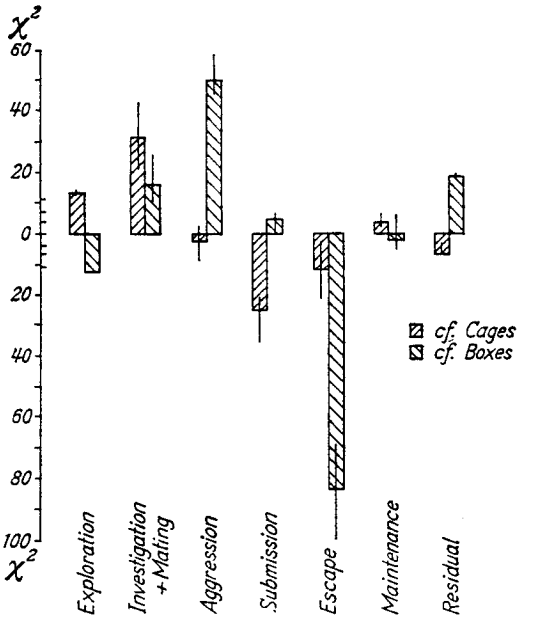

Fig. 3. Amylobarbital (5 mg/kg) given to rats living in boxes compared with controls in cages and boxes respectively

152.1, $df = 34$, and $\chi^2 = 240.5$, $df = 31$ respectively). Fig. 3 shows that in rats given amylobarbital:

Exploration was less than in box controls, but still more than in in cages.

Investigation and Mating occurred more than in either controls, especially more than in cages. (In both aspects of exploration, the influence of the boxes is discernible, though reduced). Mating was especially increased.

Aggression was much more than in box controls, almost, but not quite, as much as in cages (*Aggressive Groom* was less than in cages; the other elements were not significantly different).

Submission was slightly more than in boxes, but definitely less than in cages.

Escape was less than in either controls, strikingly less than box controls.

Maintenance was unaltered as a whole. Of single elements, *Wash* occurred less than in boxes, *Drink* more than in boxes, and *Dig* more than in cages.

Residual elements (mostly *Push* etc.) were more than in box controls, just less than in cages.

Partners meeting drug-treated rats showed fewer elements of Aggression and more elements of Flight than when they met controls.

In brief, boxes greatly inhibit behaviour involving approach (Aggression, Submission, Mating), and increase Escape from another rat (and perhaps from the box). Amylobarbital brought Aggression virtually back to the level shown by controls in cages, and Mating even beyond that. Especially did the drug reduce Escape. However, the fact that drug-treated rats in boxes showed less Escape and especially less Submission than cage controls, suggests:

i) that the boxes inhibited the Aggression of the partners, too, so that the rats had less to flee from (unlikely, because this applies also to controls in boxes); and/or

ii) that amylobarbital has in addition a specific effect of reducing Flight.

Both parts of test 13 revealed barbiturate effects like those of test 9, and so support the "responsiveness" hypothesis, up to a point. The definitive conclusions will be discussed below.

Pentobarbital sodium. Pentobarbital was used in three experiments (see the Table) in the early tests 5 and 6 (Fig. 4) in the very small dosage of 2.5 mg/kg. In test 13/1 (see Fig. 2 above) it was compared with amylobarbital as well as with saline, both drugs at 5 mg/kg, and after three days isolation.

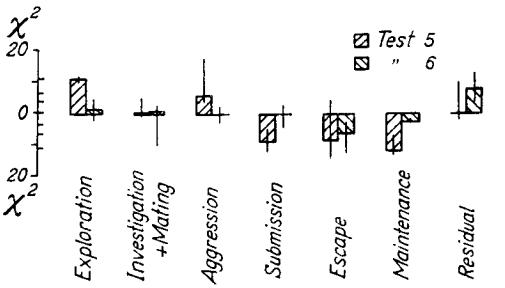

Fig. 4. Pentobarbital (2.5 mg/kg) given to rats isolated 7 days

At 5 mg/kg the barbiturates had similar effects, but those of pentobarbital were less marked. Pentobarbital increased the overall activity (actually somewhat more than amylobarbital), and reduced *Scan*, the static exploratory element. It increased Aggression and reduced Escape, but neither to the same extent as amylobarbital. The 2.5 mg/kg dose appears inadequate for large and stable effects in this situation (at least after relatively long isolation), but retained a small but consistent and just significant reduction in Escape.

It is worth noting that whereas with amylobarbital there was no trace of ataxia at 10 mg/kg (though it is noticeable at 15 mg/kg), 5 mg/kg

of pentobarbital caused barely detectable ataxia, rats very occasionally staggered. With quinalbarbital at the same dose, ataxia is very obvious for a short period.

Lysergic acid diethylamide. LSD was given in doses of 1 and 4 μg/kg after a week's isolation (test 15, see the Table and Fig. 5). It increased the activity: the total number of elements recorded for the controls was

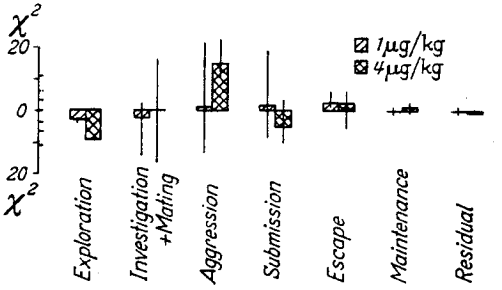

Fig. 5. Lysergic acid diethylamide (1 and 4 μg/kg), isolated 7 days

1954, for the 1 μg dose 2190, and for the 4 μg dose 2262. In the larger dose there was a definite increase in Aggression, and in both there was evidence that Aggression and Submission were intensified: the variability of both these categories is accounted for by increases in both *Sideways* postures, especially *Offensive Sideways*, and reductions in both *Uprights*, especially *Defensive Upright*. There were also fewer Mating elements, and an increase in *Stretched Attend*.

These, too, suggest increased "responsiveness". If so, shorter isolation should permit LSD-injected rats to show a more uniform increase in Aggression and perhaps Mating, as with the barbiturates. However, results after 3 days isolation (test 22/1) closely resembled those after seven days (test 15), (Fig. 6). There was about the same increase in overall activity, while reductions in the non-social Maintenance and (at 4 μg/kg) Exploration categories could be interpreted as increases in social behaviour as a whole, especially since there was some increase in Investigation also. There was the same intensification of Aggression and Submission (both *Sideways* postures increased and, at 4 μg/kg, *Defensive Upright* was reduced). Yet this remained a redistribution within categories, not a change of these (or indeed of Mating or Escape) as a whole.

The actions of LSD were in fact much closer to what one would expect of an increase in generalised responsiveness than those of the barbiturates. This could be tested further. If a drug intensifies Aggression specifically, it should do whatever the sex of the partners; if it increases a more general responsiveness, then the introduction of a female partner should intensify Mating.

The behaviour of rats given 2 μg/kg of LSD was therefore compared when meeting male and female partners, and also compared with controls meeting females (test 22/2). The animals had been isolated a further week and reassigned; the partners were all experimentally naive and, being of approximately equal age, the males were heavier. No specific control was attempted of the females' stage of oestrus (apart from keeping then in monosexual groups from weaning until simultaneous isolation,

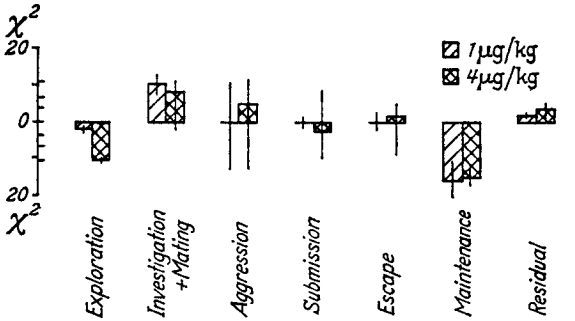

Fig. 6. Lysergic acid diethylamide (1 and 4 μg/kg), isolated 3 days

cf. PARKES and BRUCE, 1961). In the event, one of the six females in each set exhibited lordosis during the introduction. A similar experiment (test 26/2) was made using 5 mg/kg of amylobarbital, with the one difference that the male partners had been previously used, thus accentuating the difference in Aggression shown by male and female partners.

The major differences in these tests were due to the partners' sex. As might have been expected, Fig. 7 shows that in LSD- or amylobarbital-injected rats meeting females instead of males:

i) Exploration was unchanged.

ii) Investigation and Mating were greatly increased, mainly through increases in mounting and the associated elements *Follow* and *Sniff*.

iii) Aggression was somewhat reduced by LSD, especially in the more intense elements, but increased (especially *Offensive Sideways*) by amylobarbital.

iv) Submission and Escape were both reduced in both tests, fairly uniformly. The reduction was considerable except for LSD's slight effect on Escape. Flight was reduced since although female partners showed some Aggression it was much less than males.

Maintenance was increased, due to increases in self-grooming, especially *Lick*, which usually follows *Mount*.

Residual elements were also slightly reduced.

However, a picture similar to this would have been shown by controls meeting male and female partners. The interesting comparison from the

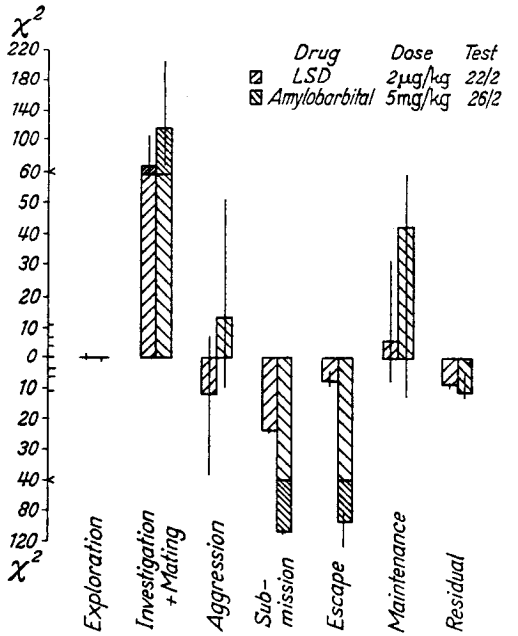

Fig. 7. Behaviour of rats given amylobarbital (5 mg/kg) or LSD (2 µg/kg) meeting female partners as compared to those given the same drugs meeting males

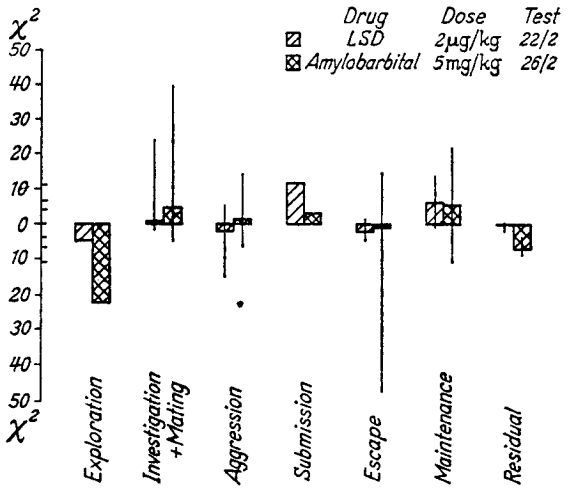

Fig. 8. Behavior of rats given LSD (2 µg/kg) or amylobarbital (5 mg/kg) meeting female partners compared with controls meeting females

point of view of drug action is that between LSD- and amylobarbital-injected animals and saline controls. LSD did not affect overall activity, but amylobarbital increased it from 1981 to 2346, 18.4%.

Fig. 8 shows that:

Exploration was significantly reduced, slightly by LSD, greatly by amylobarbital.

Investigation and Mating was little changed as a whole by either drug, but both drugs induced a very highly significant increase in *Mount*, leaving Investigation and, notably, *Attempt Mount* unchanged.

Aggression was not altered as a whole by either drug, but whereas LSD reduced *Pull* and increased *Offensive Upright* (which sometimes precedes *Mount*, and otherwise implies low intensity Aggression), amylobarbital very greatly increased *Offensive Sideways*.

Submission was increased by LSD but unchanged by amylobarbital.

Escape was not changed as a whole by either drug, but amylobarbital increased *Attend* and reduced *On Bars* considerably.

Maintenance was slightly increased by both drugs, in both cases due to the increased post-copulatory grooming.

Residual elements were unaltered by LSD, slightly reduced by amylobarbital. In brief, both drugs tended to increase the overall activity and lessen non-social Exploration; both increased the complete *Mount* to females as compared to controls, and increased *Offensive Sideways* (highly aroused Aggression, diminished Submission). However, where LSD increased *Mount* to females and *Offensive Sideways* to males, amylobarbital increased both simultaneously to the females.

Discussion

Objectivity in ethological studies is sought by making the observation as precise as possible. So far as observation is accurate, the units measured are those which animals make without specific training by the experimenter and in a relatively unrestricted situation. The experimenter may therefore attempt to record everything the rats do with reasonable hope of objectivity: his preconceptions of the function of each element may be minimised without repressing the assumption that a function exists. Motivation is distinct from function, but may always be as complex, even in a situation the experimenter considers simple; so that observation of seemingly "irrelevant" behaviour provides a useful control for the specificity of a drug's action (cf. BINDRA and MENDELSON, 1962).

The name given to a tendency may be arbitrary (and meaningful), but its existence is empirical (see GRANT, 1963): "tendency" is a word for the internal organisation relating actions having any function in common. However, the terminology provides a coherent description for changes in the occurrence of elements not only in relation to external sensory factors, but also to internal chemical ones (see also SILVERMAN, 1965 and 1966). The tendencies therefore seem likely to correspond to real neurophysiological processes, though presumably only at one important stage between stimulus and response.

The present results are consistent with the literature. Several authors have examined whether barbiturates suppress fighting, for which chlorpromazine and related phenothiazines are effective. For example, in cats, pentobarbital increases Excitement and reduces Sociability but not Hostility towards the observer, according to NORTON and DE BEER (1956), though they do not say why the elements they list should be in these categories. In mice, fighting is only suppressed by phenobarbital at seizure-preventing (TEDESCHI *et al.*, 1959) or hypnotic doses (JANSSEN *et al.*, 1960).

These methods would not be expected to reveal any increases in fighting. In newts, *Triturus viridescens* (EVANS and ABRAMSON, 1958) and Siamese fighting fish, *Betta splendens* (EVANS *et al.*, 1958), observation of threats and displays as well as the more obvious chases and bites, showed that LSD enabled low-ranking animals to move up the dominance hierarchy. It was concluded that the drug lowers the threshold for aggression. To be sure, SAXENA *et al.* (1963) found that LSD inhibited "conditioned fighting" in *Colisia labia* and led to a "severe arousal reaction" to touch, sound etc.; but even so small a dose as 0.1—0.3 μg seems excessive for a fish only 4 cm long.

Barbiturates can have effects which have sometimes (but not always) been plausibly interpreted as due to a reduction in "fear". For example, amylobarbital caused animals to approach closer to the end of an alley where they had previously received both food and shock (BAILEY and MILLER, 1952; BARRY *et al.*, 1962) or slowed down avoidance more than approach to food (BARRY and MILLER, 1965). Without reward, rats ran a strange maze better under pentobarbital (BLOCH and SILVA, 1959), though subsequent performance for food was poorer than controls. On a VI operant-schedule, pheno- and pento-barbital increased the number of shocks accepted by hungry rats (GELLER and SEIFTER, 1960).

However, other authors found no evidence that barbiturates specifically reduced avoidance. Pentobarbital slightly reduced shuttle avoidance at 5 mg/kg, but unlike chlorpromazine, also reduced discrimination of the correct route (HUGHES and ROUNTREE, 1961). RAY (1963) trained rats on two levers (to avoid shock and obtain milk respectively), and found chlorpromazine but not pentobarbital to inhibit the former specifically.

The effects of amylobarbital on rats' social behaviour may be summarized as:

1. Increasing the overall activity.

2. In most tests, increasing Aggression and often Mating also.

3. In most tests, reducing Submission and Escape, i.e. both forms of Flight.

The behavioural effects of pentobarbital were very similar, but somewhat less marked, while ataxia was evident at a lower dose. It is relevant that these effects were obtained at low doses (even psychopharmacologists often use doses of 15 mg/kg and above), and that the animals were in a situation where social tendencies would be expected to be highly aroused in any case (cf. GOLDSTEIN *et al.*, 1960; BASTIAN, 1961).

It does not seem possible to take any of these three overt effects as primary, from which the other two could be derived.

Thus, activity could well be increased without reducing Flight in absolute or relative terms, and without specifically increasing Aggression. This happened in the early follow-up tests of test 9 with amylobarbital, and in a sense with LSD. Amphetamine increased activity as a whole, nevertheless Flight was increased and Aggression reduced (SILVERMAN, 1966).

An increase in Aggression would certainly increase overall activity, but would not of itself account for increases in Mating when this occurred (tests 13 and 26/2). Similarly, increased Mating would not account for increased Aggression; and Mating was, in any case, reduced in test 9 at the small dose. In boxes, amylobarbital increasd Aggression above the box control level, and brought it up to the cage control level, but no further. Given that all the rats had been isolated for the same period, this is more what one would expect of a disinhibition of Aggression than of a specific increase. Finally, increased Aggression, or Mating, would not account for diminished Flight (tests 5, 6, 9, and 13).

A reduction in Flight alone would certainly account for many of the results: the overt reduction in Submission and Escape when they occurred; the disinhibition of Aggression and/or Mating, particularly in boxes; the relative lack of specificity in which of these was increased; and the consequential increase in overall activity. Nevertheless, in some tests (e.g. test 26/2) there was no direct evidence of reduced Flight, while the fact that Aggression was increased after three days but not always after seven, suggests an increase in something, rather than a disinhibition. (It is assumed, plausibly, that social tendencies including Flight increase with increasing deprivation of rodent companionship, though not necessarily at the same rates). So a reduction in Flight is not likely to be the whole answer.

A single, primary action should be sought, but it is not to be expected that (even with a single action at a biochemical level) a drug will necessarily have a single effect at a neurophysiological level, still less a behavioural one. The simplest description of the above results would be to classify the tendencies in a "Tinbergenian" hierarchy. The tendencies which bring one rat closer to another (Investigation, Mating, Aggression and one component of Submission) form a larger unit, to be labelled

"social behaviour". Barbiturates would be said to increase this and reduce its converse, Escape and the other component of Submission, without significantly affecting behaviour not oriented to another rat.

Yet the only measure of a tendency is its responsiveness, the elements released on a given stimulus. So, an increase in all social behaviour may mean no more than that, in this situation, the most conspicuous and novel stimuli are those presented by the other rat. The drug would have increased responsiveness in general, i.e. the same tendencies were released as in the controls, but to a greater extent.

The effects of LSD could in fact be accounted for much more neatly as an increase in general responsiveness (as distinct from the responsiveness of any specific tendency). See the notable series of papers by KEY (e.g. 1964). Total activity was increased, and so were the more "intense" elements of Aggression and Mating—the lowered threshold noted by EVANS *et al.* (1958) seems to apply within a tendency as well as to Aggression as a whole. With LSD, this intensification was specific to the sex of the partner, suggesting that such "responsiveness" applies to the selection as well as to the intensity of the tendency released. It is thus consistent that informal but fairly close observation (in daylight) of eight male rats living in pairs revealed no particular social behaviour due to LSD, but that the drug did seem to make the animals groom themselves more often. There is, however, room to argue that amylobarbital's intensification of Aggression to females (test 26/2) was "inappropriate" and that this drug had reduced discrimination (cf. HUGHES and ROUNTREE, 1961).

UYENO and BENSON (1965) report that LSD did not in fact accentuate aggression, but inhibited it in mice. However, they isolated the animals for five weeks (one day can be quite adequate for mice), so that it is not surprising that LSD increased responsiveness to the Flight-releasing stimuli from the partners as well as Aggression-releasing ones. Their descriptions suggest *Sideways* and *Upright* postures. In any case, the doses used were from 0.4 mg/kg (400 μg) upwards.

There was one other important difference between LSD and the barbiturates. LSD showed no evidence of significantly diminishing Flight. Escape was never altered as a whole, and Submission was even increased (to the females). The increase in Aggression was very consistently of *Offensive Sideways*, which reveals a low level also of Flight. Increased pure Aggression, even in only a few individuals, would have shown up as *Attack*.

Since LSD altered responsiveness without effect on overt Flight, while barbiturates nearly always reduced it, it follows that the simple explanations are probably the correct ones. Barbiturates must not only increase general responsiveness, but simultaneously reduce specific responsiveness for Flight.

It is reasonable to suppose that barbiturates can also reduce avoidance behaviour in other situations, possibly including those associated with the emotion of fear in man. Yet, at the risk of stating the obvious, Flight was reduced but not abolished, while responsiveness in general was increased. With these opposite effects, it is not surprising that animals given a barbiturate respond in an entirely appropriate direction (but less than usual intensity?) to a strong CS purely for avoidance.

Summary

1. Observing elements recognised in the behaviour of rats in each other's presence permits measurement of their social tendencies.

2. Amylobarbital sodium (2.5—10 mg/kg), and also pentobarbital sodium (2.5—5 mg/kg), increased elements classifiable as Investigation, Mating, and especially Aggression (all involving approach), and reduced Flight from another rat. Non-social behaviour was largely unaffected.

3. Increases were most consistent if shortened pre-experimental isolation or housing in boxes had left social tendencies submaximal.

4. LSD (1—4 μg/kg) intensified Aggression or Mating (according to partner's sex), without overall changes of these categories or Flight.

5. All three drugs, which increase overall activity, are considered to increase responsiveness to stimuli, barbiturates (but not LSD) also specifically reduce Flight.

Acknowledgements. Much of the work reported here formed part of a Ph.D. thesis in the University of Birmingham. I am deeply indebted particularly to Dr. M. R. A. CHANCE, to Drs. E. C. GRANT and D. A. HUMPHRIES for critical discussion, to Miss C. A. SUMMERHILL for exceptional technical and observational assistance, and to the Management Committee of All Saints Hospital, Birmingham, for financial support. The Mental Health Research Fund made a grant to Dr. CHANCE for apparatus.

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Note added in Proof. The statistical test used here was adopted as the most effective one available for routine use with a desk calculator. However, it may be advisable to note that too much weight should not be placed on the apparent level of significance of a given value of χ^2 when used in this way. Computers are now more readily available for tests which will not only reveal differences in pattern and locate them, but also give accurate levels of probability to such differences.

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