PREDATORY DOMINANCE AND AGGRESSIVE DISPLAY UNDER IMIPRAMINE TREATMENT IN CATS

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Abstract. The effect of imipramine treatment on the aggressive display and predatory dominance was tested in 16 male cats yoked in 8 pairs. Imipramine applied chronically during 3 weeks in submissive cats produced a tendency to compete with the dominant cat in a predatory situation and an accompanying enhancement of aggressive display. Some of the treated cats gained the predatory dominance over previously dominant partners. The level of aggressiveness was not, however, directly related with the process of gaining dominance. Therefore it was concluded that imipramine enhances some mechanisms involved in dominance, not limited to aggression.

INTRODUCTION

In our previous study on social and aggressive behavior in cats (10) it was found that predatory dominance in pairs of cats was not always formed on the basis of aggression. We were able to distinguish pairs in which the dominant status was correlated with a high level of aggression, as well as pairs in which gaining and maintaining dominance was accompanied by indifferent or friendly relations among partners. Five types of dominant-submissive relationships which were observed, differed from one another in terms of their stability as well as in terms of the level of aggression displayed by the dominant cat or both partners. The effect of imipramine treatment on aggressive behavior has not been
yet fully recognized. For several reasons such as differences in doses and durations of treatments, species, procedures and types of response considered, no definite conclusion can be drawn concerning the effects of imipramine and related antidepressants on aggressive behavior (see Goldberg and Horovitz review, 12). Several authors (1, 6, 18) found an inhibition of different types of aggressive behavior after imipramine in monkeys, cats, mice and rats. An excitatory effect of imipramine treatment on aggression was observed as well. Sabelli et al. (20) showed that mice given imipramine started to fight. Crowley (5) reported an increase in foot-shock induced fighting in rats after a low dose of imipramine Fonberg (8). Koczyński and Fonberg (14) described the enhancement of aggressiveness in dogs during imipramine treatment. Also in our preliminary work (9) it was found that imipramine applied chronically may produce a killing attack in cats, previously selected as non-killers. The aim of the present experiment was to study the imipramine effect on intermale aggression with respect to the dominant status in a predatory competition.

MATERIAL AND METHODS

Animals. Experiments were performed on 16 adult male cats weighing approximately 3 kg, housed individually in small cages and fed with standard food (meat soup with cereal and vegetables and milk).

Procedure. The method used to investigate predatory behavior in different situations (single cats, pairs and group of cats) as well as evaluation of the level of aggression in intermale interactions was described in detail in our previous papers (10, 21, 22).

Predatory pretest. All cats were tested individually for their predatory abilities. Each cat after 24 h of food deprivation was placed in an experimental compartment (180 × 180 cm). After 5 min a freely moving white mouse was thrown in through the window placed 143 cm above the floor. The latency of catching, killing and consuming the mouse was registered. Twenty minutes were allowed for each cat to kill the mouse. Less than 5 s of killing latency during 3 consecutive sessions was a criterion for good mouse-killers.

Observation of social interaction. The cats selected before as good mouse killers were tested in pairs (both partners after 24 hs of food deprivation) and each pair was introduced separately to the above described experimental compartment for 20 min. The pairs were yoked at random — the whole group consisted of 8 pairs. The mutual relations of both cats was observed and all types of friendly attitudes (approach, touching, grooming, licking) as well as indifferent and aggressive display
(hissing, growling, pushing, jumping, attack) and specific body postures, facial expressions and autonomic symptoms were noted. The observations of social interactions between cats were performed 2 times weekly for 5 weeks.

*Evaluation of aggression.* For each cat the evaluation of aggressive behavior toward the partner was made with the use of 3 scores demonstrating the intensity of aggression: 1 — hissing or growling, 2 — paw striking, 3 — attack. The most intensive aggressive display was used for the determination of aggression level in each particular experimental session.

*Predatory behavior in competitive situation.* After 20 min of observation of general behavior and social interactions, a white living mouse was presented to both cats simultaneously, introduced similarly as in the predatory test through the window. The latency of catching, killing and eating the prey, competitive and aggressive behavior between partners were noted. During one experimental session, lasting 30 min, three mice were offered as a rule, the next after the preceding one was killed and consumed. In the cases when the dominance status was not obvious, 5 mice during one session were offered. Ten experimental sessions were performed for all cats 2 times weekly. As dominant was considered the cat which had a priority in catching and killing the mice. Only pairs, in which dominance did not fluctuate, were used in the imipramine experiment.

*Imipramine treatment.* Imipramine (Imipraminum Polfa) was administered only to the submissive cats, which never killed the mouse in the presence of the dominant cat. The drug was injected intramuscularly in chronic conditions during 3 weeks in doses of 12.5 mg during the first week, 25 mg in the second week and again 12.5 mg in the third week, every day at 8.30 a.m. Experimental sessions were performed three times a week in about one hour after the imipramine injection.

**RESULTS**

*Competition and aggression before imipramine treatment.* According to the categorization obtained on the basis of our previous results (10), in the course of a competition test the pairs of cats were classified as belonging to following types of interpartner behavior: Type I — dominant cat displaying a strong aggression gained his status in the first experimental session, submissive cat did not act aggressively (3 pairs); Type II — both cats were fighting during a few sessions and finally one of them became absolutely dominant, the level of aggression of the submissive and dominant cats was almost equally high (3 pairs); Type V —
both cats remained in indifferent or amical relations and one of them became dominant with no signs of aggression (2 pairs). Cats of Type III and IV, distinguished in previous paper (10), in which dominance was fluctuating, were not used in this experiment. The dominance once established remained stable. The top cat was the one who always caught, killed and consumed all of the presented mice, the submissive cat never attempted to approach the mouse, observed passively the movements of the dominant cat or even drowsed. Generally, submissive cats did not display aggression, except Type II cats.

**Competition and aggression during and after imipramine treatment.**

The drug was injected to the submissive cats only. In all pairs imipramine caused a substantial change in dominance, either in respect to its stability or in terms of total reversal. During the treatment 7 out 8 submissive cats started to attack and kill the mouse and sometimes gained the dominance (Table I), or at least the status of the previously

| Table I |
|-----------------|--------------|--------------|--------------|--------------|--------------|
| The effect of imipramine treatment on the number of effective killing attacks in submissive cats |
| Cats No. | Before | Imipraminea | After |
| | | 12.5 mg | 25 mg | 12.5 mg | I sess. | II sess. | III sess. |
| 100 | 0 | 0 | 8 | 9 | 7 | 7 | 4 |
| 148 | 0 | 2 | 3 | 6 | 4 | 5 | 3 |
| 457 | 0 | 1 | 6 | 8 | 2 | 1 | 2 |
| 99 | 0 | 1 | 2 | 0 | 1 | 2 |
| 409 | 0 | 0 | 0 | 0 | 6 | 0 | 0 |
| 57 | 0 | 3 | 1 | 1 | 5 | 3 | 0 |
| 2 | 0 | 1 | 4 | 3 | 3 |
| 135 | 0 | 0 | 0 | 0 | 0 | 1 |
| \(x^2\) | 0 | 1.12 | 2.5 | 3.75 | 3.5 | 2.5 | 1.87 |

*a* 3 experimental sessions with 3 mice offered in each.

dominant cat has been weakened (Fig. 1). In some cats the effects of imipramine occurred during the treatment and overlaid it, in others the drug effects first appeared or were most marked after treatment discontinuation. Four cats started to compete effectively for the mouse already during the first dose period, two — during the second, and one — during the third. A total reversal of dominance appeared for the first time in one pair during the second dose period, in the second pair — during the third dose period. In one case the submissive cat gained dominance twice in the first session after the imipramine treatment. Some of the cats during the treatment, and also afterwards, very often
Fig. 1. The effect of imipramine treatment on predatory dominance in pairs of cats. Triangles, imipramine treated cats; circles, non-treated cats. Ordinate, number of killed mice; abscissa, successive sessions. Numbers on the right side of the picture indicate individual cats.
Fig. 2. The effect of imipramine treatment on intermale aggression in pairs of cats. Triangles, imipramine treated cats; circles, non-treated cats. Ordinate, aggressive scores; abscissa, successive sessions. Numbers on the right side of the picture indicate individual cats.
attempted to catch the prey, and even if they were not successful in killing the mouse, they demonstrated an interest in the competition, which has not been observed before imipramine, except in one pair in which the submissive cat (135) tried to get the prey twice during the observation period. This cat did not catch any mice under the imipramine treatment, however, during each session he attempted to do so. He effectively attacked the mouse in presence of his partner only once, 2 weeks after the imipramine treatment. Competition was accompanied by some aggressive display manifested by both partners (Fig. 2). Aggression was not correlated with the type of dominant — submissive relations. Table II illustrates the aggressive display in imipramine treat-

### Table II

The effect of imipramine treatment on aggressive display (determined by scores on the scale of aggression) in submissive cats

<table>
<thead>
<tr>
<th>Cats No.</th>
<th>Before</th>
<th>Imipramine*</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12.5 mg</td>
<td>25 mg</td>
<td>12.5 mg</td>
</tr>
<tr>
<td>100</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>148</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>457</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>99</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>409</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>57</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>135</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

\[X^*\] = 0.62 0.75 0.87 1.12 1.62 0.87 0.87

* Three experimental sessions with 3 mice offered in each.

ed cats according to the above described scale for evaluation of aggression. In cats submitted to imipramine treatment an increase of vocalization (hissing and growling) as well as piloerection in a competitive situation were observed already during the first dose period. At the same time, an active interest in the mouse and more or less successful attempts to catch it were noted.

The submissive cat approaching the prey usually hissed at the dominant one, and the dominant responded with hissing. In a more conflicting situation (if the submissive cat was about to catch the mouse, but finally the dominant one took it over), the submissive cat not only hissed, but sometimes also struck at the opponent, who did or did not (in a few cases) respond. It happened also that hissing or growling was initiated by the dominant, evoking a similar response in the submissive cat. In one pair (139 - 99) however, during 3 consecutive sessions the
dominant cat’s “warning” remained without response — the same took place occasionally in 3 other pairs. In pair 139-99, in the first experimental session after the imipramine treatment, fighting was observed. These cats were never fighting before (Type V of dominant-submissive relationships). In this pair the submissive cat very often attempted to catch the mouse, demonstrating a strong interest in the competition, however he was successful only 3 times during the treatment. In a non-competitive situation i.e., before the mouse was offered, the imipramine treated cats as well as non-treated ones sometimes hissed or struck at each other.

General behavior. The influence of imipramine on general behavior was not uniform in particular cats. Generally it was not dose dependent. Some symptoms, like an increase of vocalization (miaowing, hissing, growling), piloerection and pupil dilatation and a kind of hypersensivity to noise were observed in all cats. The increased activity was always directed to the goal (i.e., mouse). Before the treatment, submissive cats did not involve themselves in any kind of activity in the experimental cage. Under and after the treatment their activity was connected strictly with the competition for the mouse.

In three cats vomiting was noted after consuming the prey. In some cats a tendency to play with dead or live mouse was observed more often than before the treatment. Even in the effective predatory attack some decrease in precision of movements was observed (the killing grip was not always typically pointed at the neck, but at other parts of mouse’s body) — it was especially pronounced in cats 457 and 99 and particularly after the second (25 mg) dose. In some cats the latency of consuming the prey was prolonged.

Beginning from the first dose period hissing on the experimenter occurred, although generally the handling has not become harder. The injection itself seemed to be aversive — cats struggled, tried to escape, miaowed and hissed.

DISCUSSION

The results of our experiment show first of all that imipramine does not supress the predatory behavior in cats, which is in contrast with the results obtained by other authors concerning the muricide behavior in rats. It has been proved in several studies, that imipramine and other antidepressive drugs selectively inhibit mouse killing in rats (12, 13, 15). Our findings, however, support the view that predatory behavior in cats represents a different class of behavior than mouse-killing in rats (21) at least in terms of motivation. We think that predation itself should not be treated as a category of aggression. In our model of
experiment the prey-object is considered only as a competition evoking stimulus. Our experiment (Figs. 1 and 3) clearly showed that imipramine evokes predatory competition and produces in the submissive cat a tendency to get the predatory dominance over his partner. Even if the dominance was not complete, all of the cats in comparison to the pretreatment level, actively participated in competition and were able to catch and eat some of the offered mice. Only one cat, in spite of his attempts evoked by imipramine, was not able to dominate his partner. However in this pair the history of the dominant cat revealed that his tendency to leadership was extremely high, in previous experiments he always dominated all the partners he has been paired with.

The interesting point is that dominance evoked by the imipramine treatment does not seem to be gained by means of aggressive behavior of treated cats. Aggressive display, however, accompanied the compe-

Fig. 3. A typical situation of competition before and under imipramine treatment. A submissive cat (imipramine treated) is denoted by an arrow.
tition and was manifested by both partners. Before the treatment the relations between the submissive and dominant cat in respect to their aggression level were very clear. In three pairs the dominant cat gained his status by acting aggressively, the submissive cat did not display aggression. In three other pairs both partners were aggressive on approximately the same high level. In the last two pairs the partners remained in indifferent or amicable relations, never displaying aggression toward each other. Under the imipramine treatment the aggression level of both partners in each pair increased. Shortly before the treatment, since the dominance was very stable, the cats, even if they were classified as aggressive, only in few cases displayed aggressive symptoms (although hissing and paw striking was observed in all 3 pairs of Type II interpartner relations). During the imipramine treatment both partners, either previously aggressive or previously friendly, started to react in a hostile manner. Increase of interest in the mice, attempts to catch and kill them were accompanied by hissing and growling displayed by the submissive cat, which in turn produced a similar response of the previously dominant one. Hissing on both sides was probably of a warning nature. In few cases in response to hissing the previously submissive cat displayed paw striking, which may suggest the enhancement of aggressiveness, but it might be the result of a growing conflict produced by an increase of predatory motivation rather than the imipramine injection. The same concerns the fight which happened once between cats classified previously as being in amicable relations (Type V). Except one pair, in which the submissive cat was hissing without the response of the dominant partner and an other pair, where contrariwise, the hissing of the dominant cat did not evoke a similar response of the submissive cat, the aggressive display (including paw striking) was always parallel in both rivals. It has been found (3) that imipramine might produce aversiveness, what in turn might contribute to aggressive behavior. In case of our results parallelism of aggressive display in treated and nontreated cats does not indicate that aversive factor is involved in behavior manifested by imipramine treated animals. It should be stressed also, that we did not observed any obvious signs of illness or toxicity in treated cats.

As can be seen in the Table I, the effect of imipramine was clearly cumulating — the highest amount of effective killing attacks in the presence of the opponent happened after two weeks of treatment — it overlasted the treatment and in the third experimental session after the treatment it was smaller, but still higher than in the first week of imipramine injection. The cumulating effect of antidepressant drugs, including imipramine, is well known in human patients. Differently from
other investigators, who used imipramine in acute experiments, we injected it chronically. It could be the reason of the discrepancies between our results and the results of those authors who found the inhibition of aggression after imipramine treatment (12, 13, 15). Since social interactions were observed only between competitive partners and competition may be considered as a main conflict in this particular experimental design, we are not able to determine whether the increase of intermale aggression was the result of imipramine treatment or just a secondary effect of a conflict situation. The course of competition and the general behavior of treated cats suggested however that aggressiveness is rather an accompanying behavior than the reason for competition. Especially, because it has been found by several authors (4, 11, 17, 18) that imipramine caused an increase of “hiss threshold” and prevented the attack in cats. These data suggest that pronounced hissing observed in our cats might be a result of the growing conflict of interests between partners. We cannot exclude some involvement of elevated aggression in the process of gaining dominance, but the tendency to predatory dominance does not seem to be solely produced by the increased level of aggression in the treated cats.

This conclusion is in agreement with our previous observation that dominance is not exclusively based on aggressive mechanisms, for it may be formed and sustained without aggression (10). The role of imipramine in aggressive behavior is found to be controversial. Its mechanism of action is still far from being fully understood, it is known however that imipramine acts both serotoninergically and cholinergically (16), which is often used as an explanatory basis for the suppression of attack behavior observed by some authors. However, we have not found the inhibition of aggression, our experiments also do not fully support the view that imipramine excites aggressive mechanisms. It should be taken into consideration that imipramine may enhance some other mechanisms included in determining the dominance. According to Fonberg (7), in motivated behavior the evaluation of efficacy of the ongoing action is an important factor in determining the quality of behavior. Under imipramine treatment the self-evaluation of the possibilities of the treated cats and the self-evaluation of the efficacy of their behavior may be elevated. The adrenergic action (16) of imipramine may also produce an increase of the positive reward system and therefore enhance motivation to catch the mice. It is possible (2) that imipramine acts directly on the positive amygdalar system or/and in the amygdalar structures involved in predatory behavior (21). Our preliminary work on imipramine treated non-killer cats (9) indicates that the drug enhances predatory motivation. In the present experiment all cats were se-
lected as good killers, in the sense of their predatory abilities. The predatory motivation of submissive cats seems however to be not sufficient to make them compete with other very good killers. In social situation predatory behavior is in these cats inhibited. Imipramine might therefore act specifically on a predatory motivation. The increase of a positive motivation and self-confidence may produce conditions sufficient for the submissive cat try to gain the dominance. The rise of self-confidence and positive motivation is probably also the reason of the beneficial effect of imipramine in the treatment of depressive patients.

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REFERENCES


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